MAY
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WITH ELECTRICAL CONTRACTING

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SELECTING
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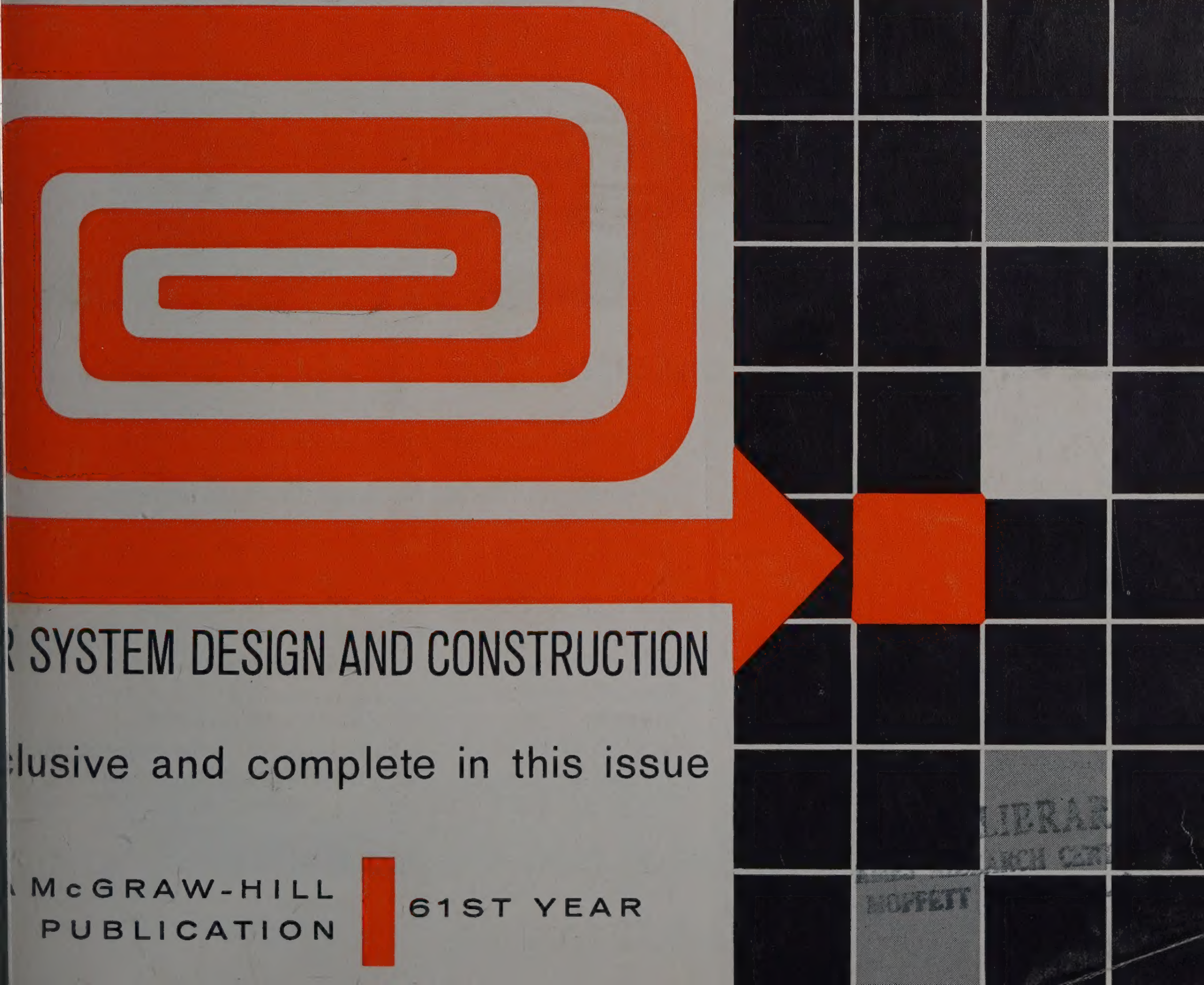

SYSTEM DESIGN AND CONSTRUCTION

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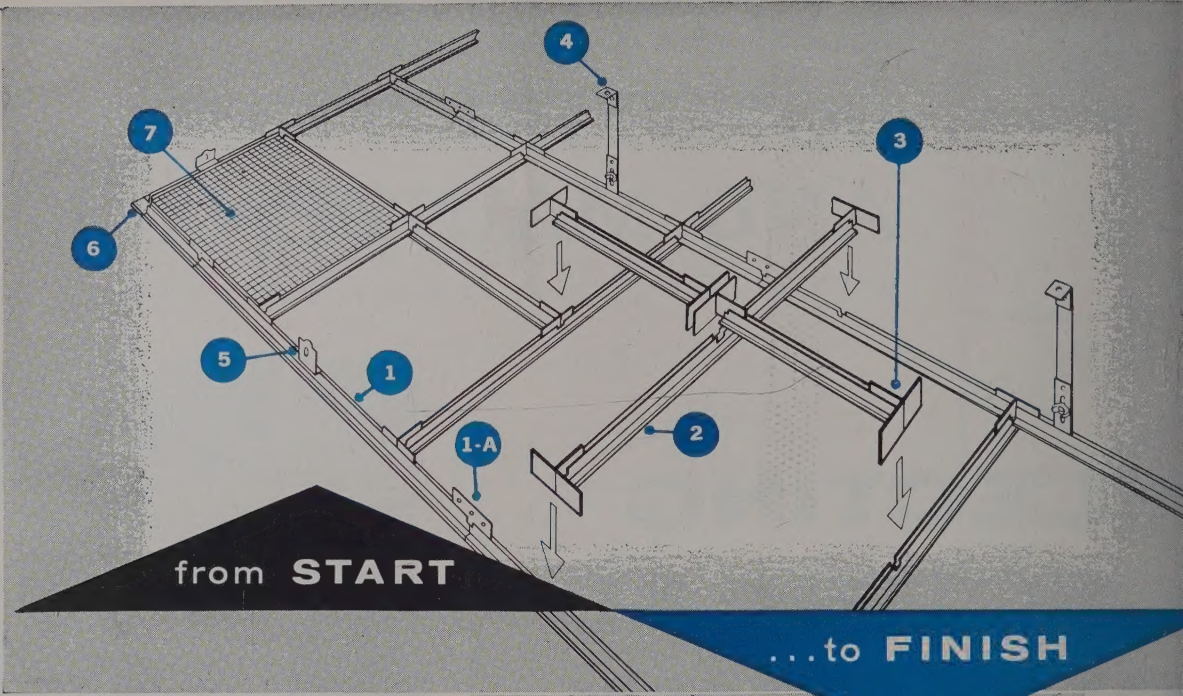

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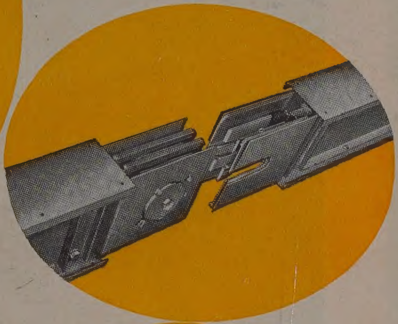

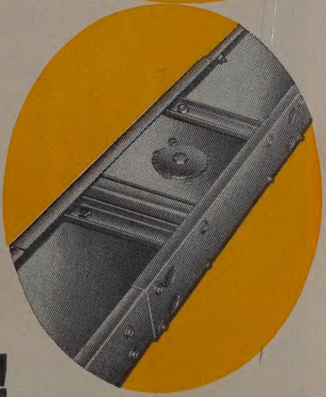

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and MAINTENANCE

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ELECTRICAL CONSTRUCTION AND MAINTENANCE

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Published for electrical contractors, electrical departments in industry, engineers, consultants, inspectors and motor shops. Covering engineering, installation, repair, maintenance and management in the field of electrical construction and maintenance.

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SILICONE NEWS from Dow Corning

Blueprint for Reliability

For Performance Plus...Specify Silicone Insulated Transformers

Here's Why—(1) *Low cost installation* . . . transformers using silicone insulation systems are up to 50% lighter, 50% smaller and require no costly vaults or barriers. (2) *Lower operating costs* . . . silicone insulated transformers are virtually maintenance-free — have no liquids to filter or change — need no space heaters to keep de-energized windings dry. (3) *Maximum safety* . . . silicone insulated transformers are completely dry. There's no danger of toxic fumes, or fire. (4) *Maximum reliability* . . . silicone insulated transformers operating at 200 C have a longer life expectancy than Class A transformers operating at 100 C. Depending on design, silicone insulated transformers withstand overloads of 25 to 50% above rated capacity. Units have been flooded without damage to windings.

Here's How — Dow Corning silicone insulation has excellent electric strength and is unaffected by thermal cycling and high temperature . . . enables transformer manufacturers to (1) produce lighter, more compact units — units that double capacity without increasing space or weight requirements; or (2) build units that withstand substantial overloads.

Here's What — Silicone insulated dr
type transformers in three enclosures: (
open, (2) enclosed and (3) gas-filled seale

Here's Where — For load center subst
tions, a choice of enclosed, open or seal
gas-filled dry-type transformers that requi
no costly vaults—can be located on roofs
balconies to conserve valuable floor spac

Here's When — Right now! Whether y
are planning for future growth, expandi
present facilities or replacing old equi
ment, consider the possibility of using si
cone insulated transformers. Initial pri
is competitive, and, when you consid
their lasting values, silicone insulated tran
formers give you more for your money .
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Sidelights

SELECTING ELECTRICAL EQUIPMENT

The book-length editorial feature in this issue is an original project prepared exclusively for our readers by our own team of engineer-editors and coordinated by Associate Editor Joseph F. McPartland.

TOOLS AND METHODS

With rising wage rates and still critical shortages of skilled manpower, electrical contractors are searching everywhere for tools and equipment to cut costs, to improve productivity and to promote safety. Effective job mechanization and sophisticated tooling have the added advantage of attracting superior youngsters to the craft and extending the effectiveness of highly skilled older mechanics. In response to the problem, Associate Editor August Eckel has been bringing together a comprehensive and up-to-date round-up of job-tested equipment and tooling in current use. A special report is now in preparation and scheduled for the July issue.

CODE CHANGES

The next revision of the National Electrical Code is expected to be released in September. It is now in pre-print form for discussion in the final formal stages leading to adoption by the NFPA. A considerable number of revisions are forthcoming. Associate Editor John H. Watt has been following the proceedings of the various code-making panels and will be in touch with developments in the final stages. He is preparing a summary and discussion of the significant new provisions of industry-wide importance in a report scheduled for the August issue.

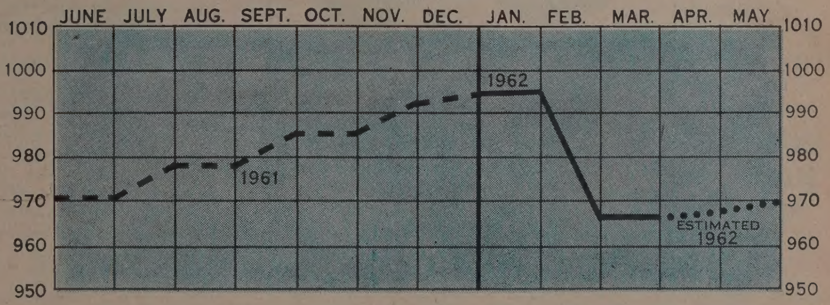
ELECTRICAL MATERIALS COST INDEX

CHANGES IN THE COST OF ELECTRICAL MATERIALS FOR EACH OF THREE TYPICAL JOBS ARE SHOWN ON THESE THREE CHARTS.

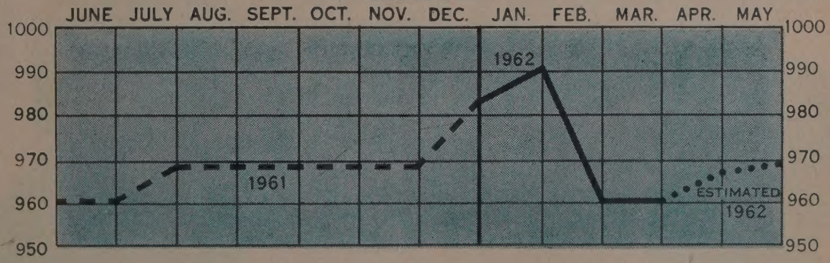
THE BASE (1000) REPRESENTS THE AVERAGE COST OF THE MATERIALS FOR THE YEAR 1960

THE MONTHLY INDEX POINTS SHOW THE VARIATIONS IN COST ON THE FIRST OF EACH MONTH.

RESIDENTIAL



COMMERCIAL



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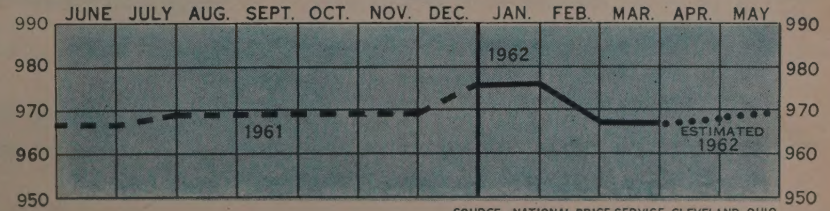

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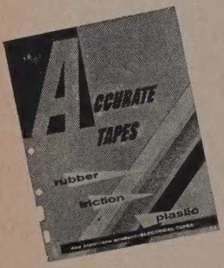
A complete guide to electrical tape—the new

ACCURATE CATALOG



The handy reference literature tape users and buyers will find invaluable. To receive your file copy, just call or write Accurate Manufacturing Company, Garfield, New Jersey, and ask for catalog # 49.

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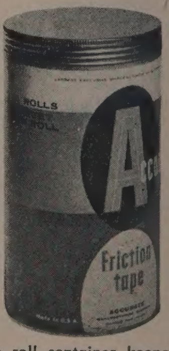

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WAREHOUSE STOCKS and REPRESENTATIVES IN ALL PRINCIPAL CITIES

Washington Report

MAY • 1962

Governmental actions instituted by President Kennedy were used to turn back a $6-per-ton steel price increase during the second week of April, in what has been aptly described by the administration's critics as "a display of naked power politics never seen before in this nation." First announced by U. S. Steel Co., and then followed by six other steel producers, the price increase was needed to meet increasing costs, for modernizing and automating steel plants, and to keep American steel competitive in world markets. The increase was rescinded 72 hours later as a result of Presidential pressure.

Many businessmen interpreted President Kennedy's angry attack on steel as an attack on the profit system itself, a fiat against price increases, and the beginning of an era when the White House, not the market, will determine price levels. In a subsequent press conference, President Kennedy said there is "no room for ill will," and that business and government must live together. During this period it was dramatically demonstrated that the powers of the federal government can be used as an economic regulator, and that the implications of this victory will be felt throughout the economy for a long time to come.

Construction spending in March declined to an annual rate of $56.6 billion, seasonally adjusted, the lowest level in ten months, Census Bureau reported. This was up 1.5% from March a year earlier, however. The government forecast for construction in 1962 is a record $60 billion.

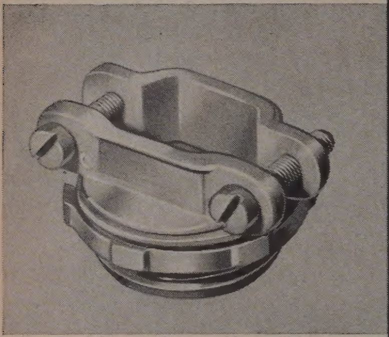
Actual total construction in March was $4.1 billion, up 8% from February. Of this total, $3 billion was for new private construction outlays, and the remaining $1.1 billion was for public construction spending.

First quarter new construction spending totaled $11.9 billion, up 3% from the first quarter expenditures in 1961. Private construction was up 5% to $8.7 billion for the quarter, while public construction dropped 2% in this period to $3.2 billion.

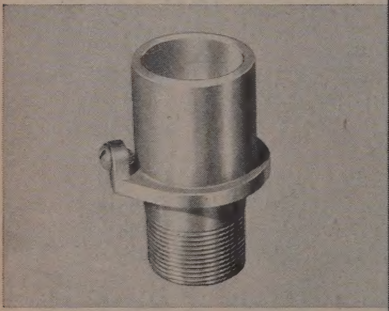
Housing construction showed renewed strength in March, after having declined for four months in a row. Work was begun on 115,700 new homes, or a seasonally adjusted annual rate of 1,409.000 units, 23% above the February rate. This was also a 9% increase over housing starts for March 1961. Based on a high backlog of unused building permits, a brisk home building construction pace is forecast for the months just ahead.

Business improvement continues, but it lacks steam. Gross national product for the first quarter was nearly 10% ahead of a year earlier, at slightly less than $550 billion. The Kennedy Administration had projected a $553 billion GNP annual rate. Over-all industrial production in March set a new record of 115.8% of the 1957 average, for the second monthly gain in a row. Personal income also hit a new record—$435.3 billion at a seasonally-adjusted annual rate. This is up nearly $30 billion from March of last year. Retail sales were up in March to a seasonally-adjusted level of almost $19.3 billion, a record, and surpassing the previous high of November 1961. The average work week rose to 40.3 hours in March, and average weekly earnings rose 71 cents from February, to $95.91, principally because of the longer work week.

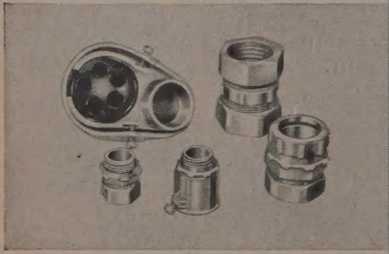
NEW FROM RACO



Oval Service Entrance Cable Connectors. These new pressure-cast oval service cable connectors feature a newly designed shorter throat. The sturdy, non-watertight connector attaches easily to service entrance switch. Clean, smooth threads and burr-free edges eliminate danger of wire snagging and damaged cable. Available in five sizes from ¾" to 2".



Offset Mast Base Reducer. New Raco offset mast base reducer threads directly into meter box. No nipple needed. One piece for easier, faster handling. Offset design makes it perfect for use next to a wall. Available in four popular sizes—2"-1¼", 2"-1½", 2½"-1¼" and 2½"-1½".



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- Rigid Conduit
- E.M.T. (thinwall conduit)
- Armored bushed cable, flexible metallic tubing and non-metallic cable
- Service entrances

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Raco 4" square box with one-screw ear.

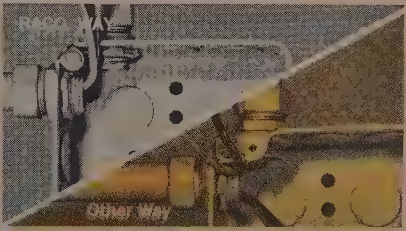
One-screw ear gives you flexibility

MORE WORKING ROOM

Raco one-screw ear design boxes give you more working room. Result: More wiring room, all KO's usable, two extra runs per box.

NO EARS TO CLIP

No lost motion clipping ears. No screws to move or lose using Raco one-screw ear boxes.



NO WIRE SKINNING PROBLEMS

With Raco's **one-screw ear** design, wire comes through clean—no skinning. You have more room. Smaller ears don't get in the way.

MOUNTS IN ANY POSITION

Whatever position you mount these versatile boxes in, you're always right. You can't install them wrong.

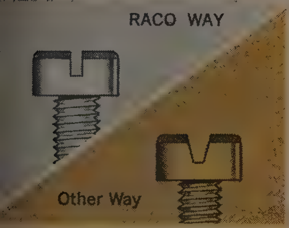
SPECIAL APPLICATIONS

Due to the design of Raco's **one-screw** ear box, you have plenty of room for despard devices or as a transformer housing.

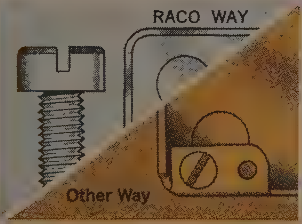
HEAVY DEVICES MAY BE USED

The one-screw ear gives you more working room when installing switches and heavy duty receptacles. Get speedier installation.

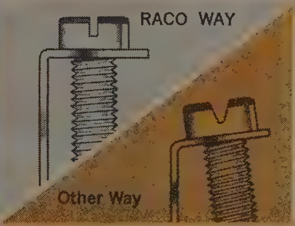
Raco quality saves you money



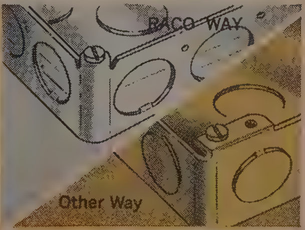
SQUARE SCREW SLOTS. A screw driver won't slip out of the milled slots in Raco screws. No wasted motion—no loss of time.



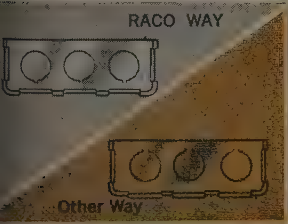
SCREWS PLATED SEPARATELY. Every screw—and every clamp—is plated before it is put in a Raco box. No rusting. Little details pay off in big savings.



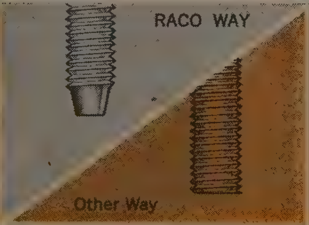
SQUARE EARS. Ears on Raco boxes are always 90° angle. You waste no time "pulling down" ears. Raco boxes are always square, never distorted.



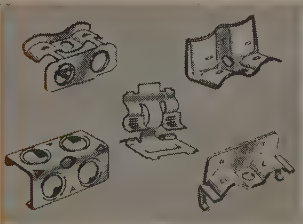
KO TIES AT BOTTOM. You can reach in a Raco box and remove any knockout with ease. Just twist, pull and you're ready to roll. Try it.



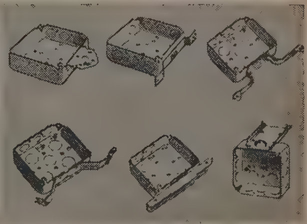
BOTTOM KO's. Clean-cut, Raco bottom KO's are on the inside of the box. It's easier to reach in, than around.



DIE-POINTED SCREWS. Raco's specially designed die-pointed screws go in speedier and easier. The time saved adds up to big dividends for you.



CLAMPS FOR EVERY JOB. There's a Raco one-screw ear box with a metallic or non-metallic cable clamp you need. • Q clamp • X clamp • L clamp • C clamp • N clamp



WIDE RANGE OF MOUNTING BRACKETS. Raco 4" square boxes are available with these brackets. • B bracket • O bracket • F bracket • A bracket • W bracket • J bracket

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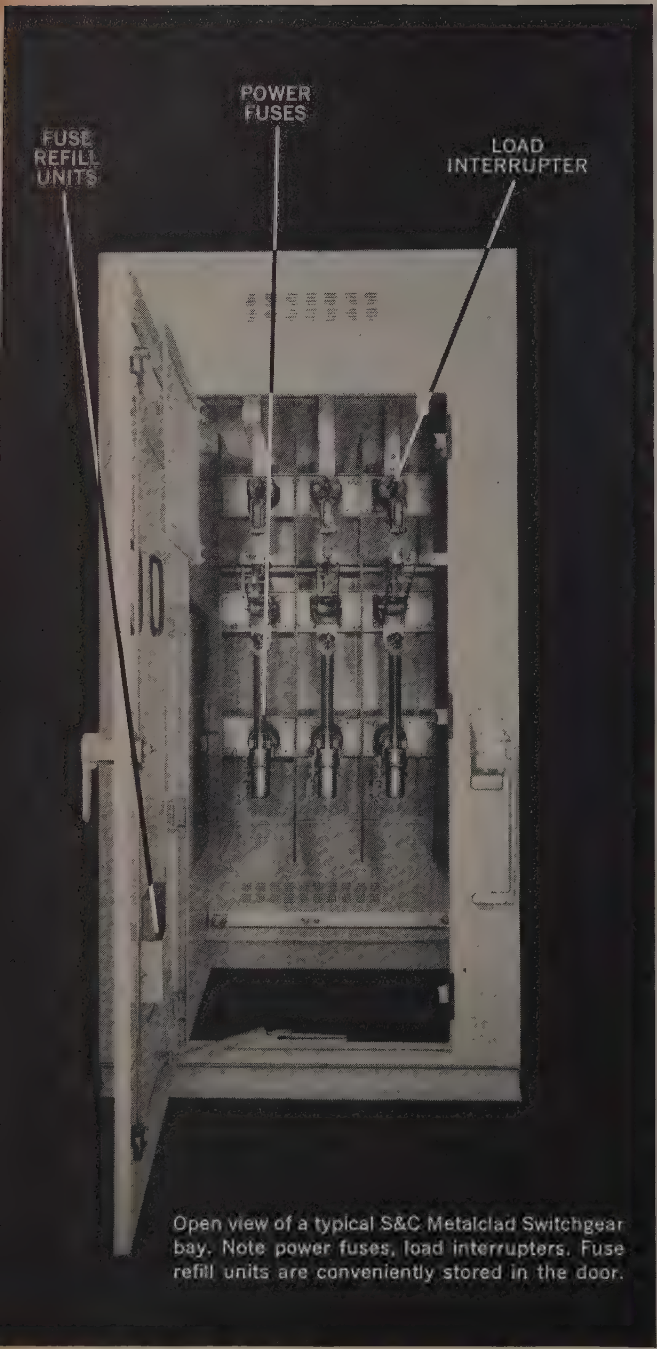
ALL-STEEL EQUIPMENT INC., Aurora, Illinois

The 500,000-kva "compact"



Open view of a typical S&C Metalclad Switchgear bay. Note power fuses, load interrupters. Fuse refill units are conveniently stored in the door.

S&C Metalclad Switchgear provides maximum protection in a minimum of space

1. Compact construction. 2. No need for rear access. 3. No front drawout. These features permit S&C Metalclad Switchgear to be installed against walls, in corners, along passageways, even in vaults and on balconies too small to accommodate circuit breaker type gear.

Unlike expensive circuit breaker type switchgear, S&C gear with fused load interrupters requires no exercising, periodic checkouts, or adjustments. S&C Metalclad Switchgear is as economical on maintenance as on space.

These advantages result from the simplicity of the S&C design, which uses power fuses for short circuit protection and load interrupters for manual or automatic load switching. Power fuses give the protection needed against permanent destructive faults. Since industrial and commercial high voltage circuits are not subject to transient faults (such as lightning, falling trees, ice, rodents), they don't need the costly repetitive and automatic reclosing features of the circuit breaker.

Compact S&C Metalclad Switchgear is available for indoor and outdoor service, with short circuit interrupting ratings up to 500,000 kva at 13.8 or 14.4 kv, and 250,000 kva at 4.16 kv (with fault closing ratings to match). Continuous current ratings are 200, 400, 600, and 720 amperes with fuses, and 1200 amperes without fuses (with load switching ratings to match). Further details are available from any S&C sales office, listed in the Yellow Pages (under "Electrical Equipment"). Or write to:

S&C OUR GOLDEN JUBILEE

S&C ELECTRIC COMPANY
6605 Ridge Boulevard • Chicago 26, Illinois
Specialists in High Voltage Circuit Interruption since 1911

S&C Metalclad Switchgear meets all National Electric Code requirements for fault closing, short-circuit interruption. Performance proved by high power testing at KEMA laboratories.

The modern, yet rustic design of this home by R. C. Broward, AIA, makes it an integral part of the wooded site on beautiful Laurel Grove Lane in Orange Park, near Jacksonville, Fla

In Jacksonville, Florida, this home sells for $27,500

("...and concealed telephone wiring helps sell it for us," says builder William M. Hall)

"Putting concealed telephone wiring in every home we build is automatic with us," says Mr. Hall, president of Hall Enterprises, Inc.

"It's a mighty good investment. In today's competitive market, customers just expect that 'extras' like concealed telephone wiring are part of good design. And it's no problem to furnish this 'extra.' The Telephone Company makes the installations quickly while the homes are being built.

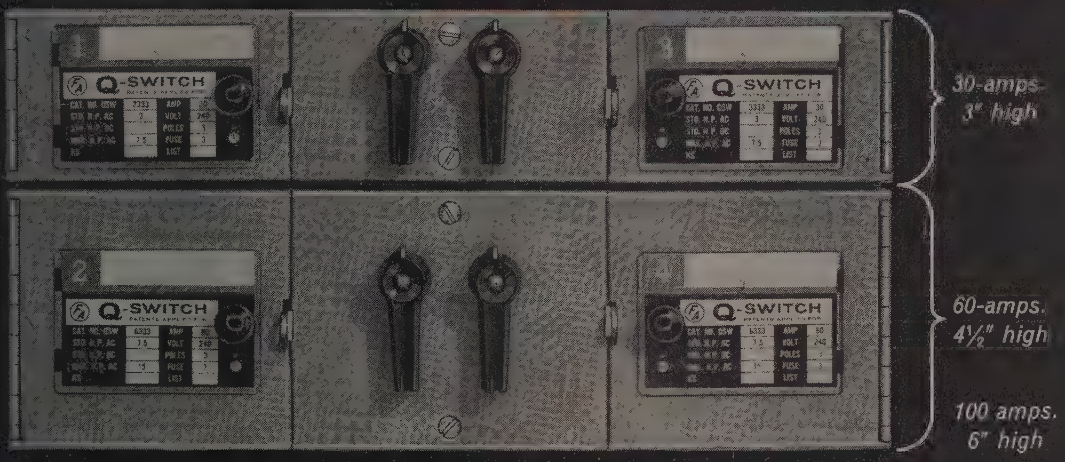
"We always display a PRINCESS phone in the master bedroom and, often, we have a color wall phone placed in the kitchen to complement the over-all color scheme. These are eye-catching sales tool just like our built-in appliances."

• • • • •

For more information on concealed tele phone wiring and other telephone-plannin ideas for builders, just call your Be Telephone Company Business Office. An see Sweet's Light Construction File 11c/Be. For commercial installations Sweet's Architectural File, 33a/Be.

BELL TELEPHONE SYSTEM

NEW! FRANK ADAM Q-SWITCH



FOR DISTRIBUTION PANELBOARDS AND FRONT-CONNECTED SWITCHBOARDS—A BREAKTHROUGH IN FUSIBLE QUICK-MAKE, QUICK-BREAK SAFETY!

- Smaller in height but more efficient, more dependable.
- Greater accessibility for easier, faster fuse replacement. Finger-tip switch operation.
- Each switching pole in individual housing of high dielectric strength bakelite for ultimate safety. Switching poles are fully isolated from fuse compartments.
- Interlocking fuse compartment doors cannot be opened when switch is "on." All exposed parts are dead when switch is "off." Interlock has defeatable feature requiring special instructions to authorized persons. Doors can be padlocked in "on" or "off" positions.

FAILURE-FREE!

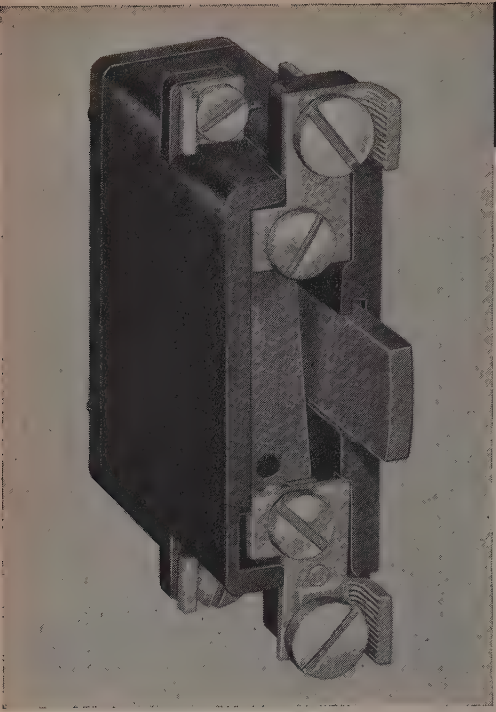
Regular out-of-stock switch subjected to nearly 60,00 operations when test was stopped because unit was still good as new!

Switch Capacities: 30, 60 & 100 amps., 240-v; 30 & 60 amps., 480-v.

WRITE FOR INFORMATION

FRANK ADAM ELECTRIC COMPANY
SINCE 1891
P. O. BOX 357, MAIN P. O. • ST. LOUIS 66, MO.

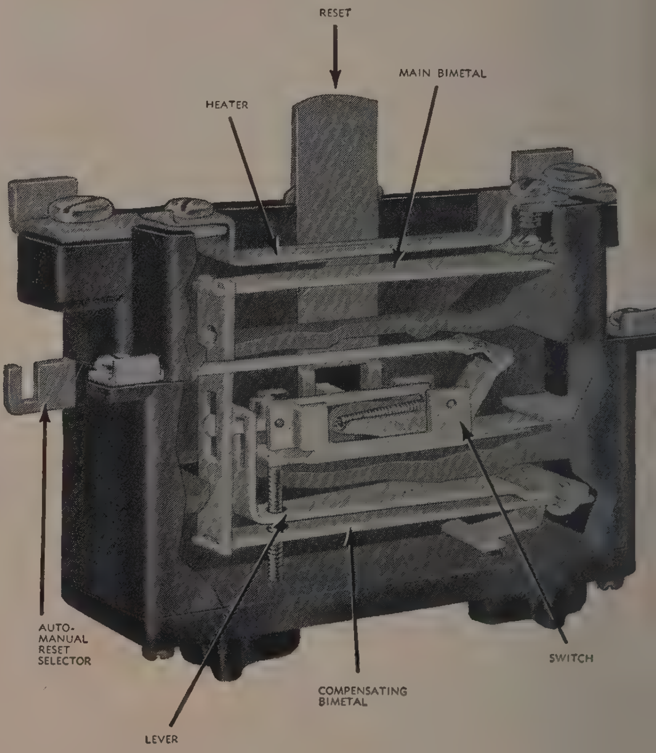
busduct • panelboards • switchboards • service equipment • safety switches • load centers • Quikheter



NEW

TEMPERATURE COMPENSATED MOTOR OVERLOAD PROTECTION

Motors are protected even though the temperature surrounding the relay differs from that around the motor. Trip time remains constant between –20°F and +170°F.



INDEPENDENT TRIP TIME—Temperature compensating mechanism maintains fixed trip travel distance regardless of ambient temperature. Movement of bimetal controlling relay trip is responsive to heat from motor current passing through heater element.

MANUAL OR AUTOMATIC RESET—just position reset selector for desired operation.

TRIP FREE—overload relay contact is independent of reset mechanism on overload.

STANDARD OR QUICK TRIP—either trip speed obtainable by using proper Furnas heater element.

COMPACT DESIGN—similar in size to melting alloy type. Easily assembled on Furnas magnetic starters without significant dimensional change.

IMPACT AND HEAT RESISTANT—constructed of materials chosen to resist rough treatment and extreme heat.

Reliable Furnas ambient temperature compensated relays are extremely versatile, each providing a choice of manual or automatic reset with either standard or quick trip heater.

For more information, write for Bulletin 48-B1, 1067 McKee Street, Batavia, Illinois.

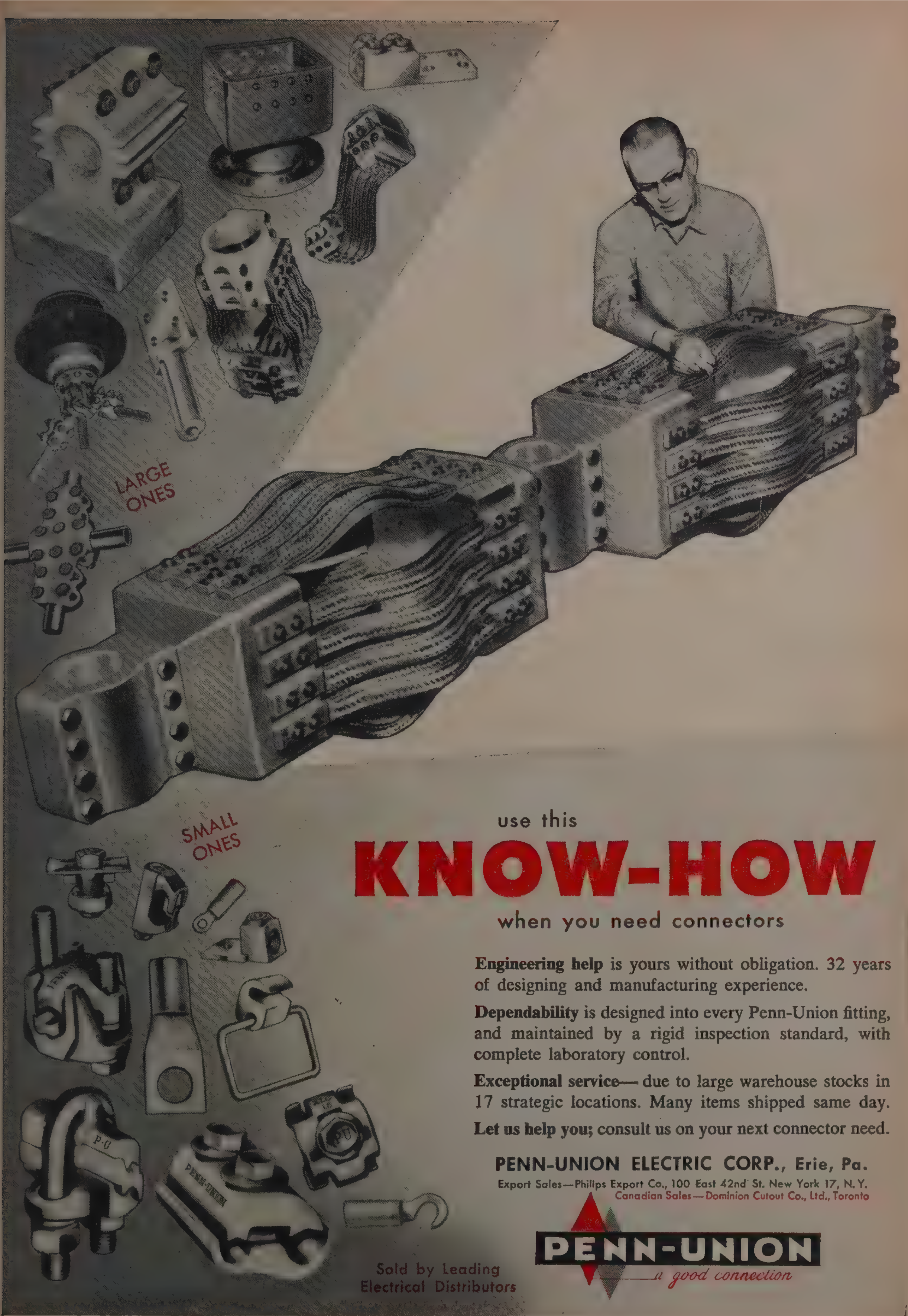
A120

FURNAS ELECTRIC COMPANY

BATAVIA, ILLINOIS

Sales Representatives in all Principal Cities

FURNAS



use this

KNOW-HOW

when you need connectors

Engineering help is yours without obligation. 32 years of designing and manufacturing experience.

Dependability is designed into every Penn-Union fitting, and maintained by a rigid inspection standard, with complete laboratory control.

Exceptional service— due to large warehouse stocks in 17 strategic locations. Many items shipped same day.

Let us help you; consult us on your next connector need.

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Export Sales—Philips Export Co., 100 East 42nd St. New York 17, N.Y.
Canadian Sales—Dominion Cutout Co., Ltd., Toronto

PENN-UNION
a good connection

Sold by Leading
Electrical Distributors

A new fast-acting multistage electric heating relay from Honeywell

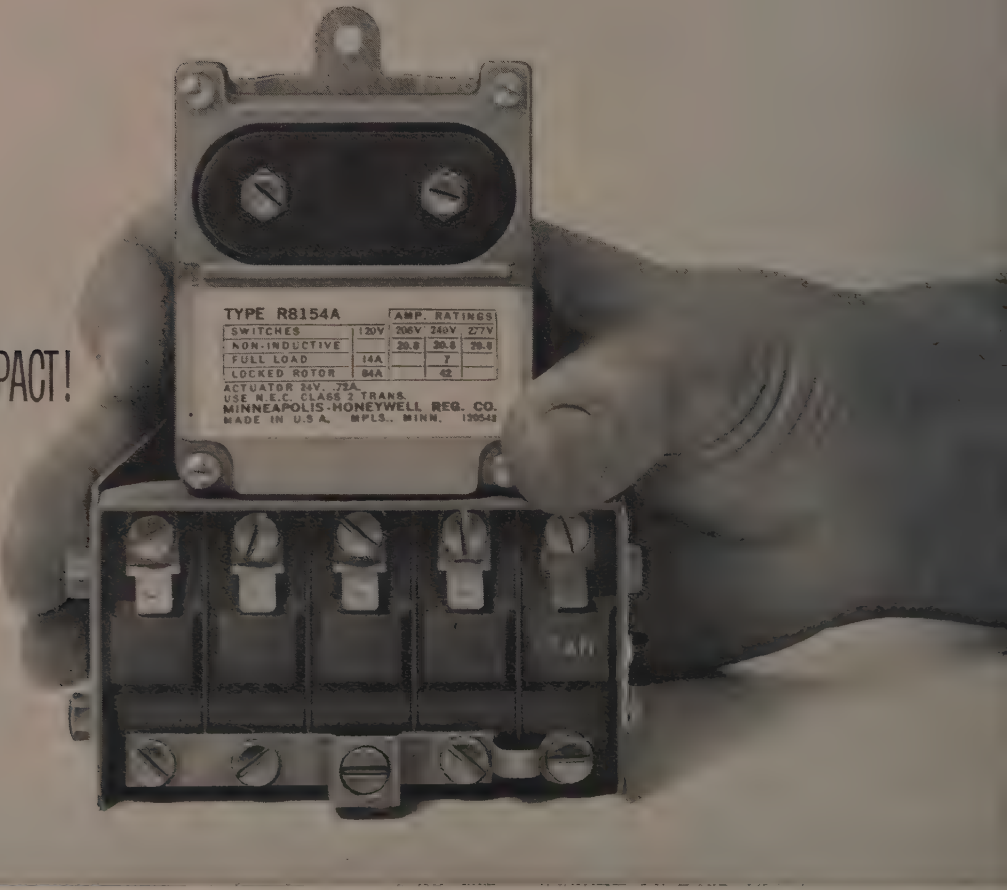
Switches up to a 25kw load in 5kw steps

- The new R8154 electric heating relay is smaller than you ever thought possible. Silent switching, too.
- Eight models from two switch to five switch, line and low voltage. Ideal for electric furnaces, duct heaters. U/L approved.
- Extremely simple to understand (and service), connections for #4 wire. Integral fan switch.
- Two relays in combination handle larger furnaces. (Step-starting each 5kw heater.)

NEW, EXCLUSIVE ELECTRIC HEAT TRAINING PROGRAM! Another Honeywell first! Sales and service meetings studying a new working manual: "Automatic Electric Heating". Ask your nearest Honeywell office about the next session.

Honeywell

H HONEYWELL *First in Control*


COMPACT!
TYPE R8154A
AMP. RATINGS
SWITCHES 120V 206V 240V 277V
NON-INDUCTIVE 20.8 20.8 20.8
FULL LOAD 14A 7
LOCKED ROTOR 84A 42
ACTUATOR 24V. .72A.
USE N.E.C. CLASS 2 TRANS.
MINNEAPOLIS-HONEYWELL REG. CO.
MADE IN U.S.A. MPLS., MINN. 120543

See your wholesaler, call your Honeywell sales office or write Honeywell, Dept. EC5-114, Minneapolis 8, Minnesota

We did a fair job in Seattle

(come see it)

You have to watch costs even on an $80 million job. That's why 15 major contractors of the Seattle World's Fair standardized on Ramset Powder Actuated tools and fasteners.

The 600-foot Space Needle that's the official symbol of the Fair is a Ramset job. The superintendent of the electrical contractor for it estimates a 50% saving on every fastening, using Ramset instead of drills and tapping and machine screws.

So many other contractors reported similar savings that Ramset is the official maintenance tool for the entire Fair, too. Two Duo-Jobmaster® fastening tools are always on hand for fast, low-cost repairs whenever they're needed. So you might say we started out doing a Fair job and we're going to keep right on doing it.

And you know, if Ramset can save money on an $80 million job, it can save you money, too. Money you can use to come see the Fair.

Ramset® WINCHESTER-WESTERN DIVISION **Olin**
285-E Winchester Avenue, New Haven 4, Conn.

WHISPER-QUIET

WAGNER® POLYPHASE RESILIENT-MOUNTED MOTORS

(Ratings Through 10 HP)

CEILING, SIDEWALL OR HORIZONTAL MOUNTING

You can mount these motors on walls or ceilings by rotating the cradle base 90° or 180°. Motor stays dripproof.

When you need polyphase motor drives that are *quiet* in operation . . . in hospitals, schools, churches, office buildings, radio or TV stations and similar locations . . . specify Wagner® Resilient Mounted Polyphase Motors.

These smooth running *standard* motors are cushioned in cradle bases by neoprene mountings, bonded to steel rings. This construction absorbs the small running vibration that remains in the most carefully dynamically balanced motor.

Apply them to fans, blowers, centrifugal pumps, compressors, and commercial refrigeration and air conditioning equipment. You'll get ultra-quiet operation. Only Wagner can provide an entire range of ratings through 10 horsepower—and Wagner is a name you can depend on for quality motors.

Your nearby Wagner Sales Engineer can help you select the right motor for your application. There are Wagner branch offices in 32 principal cities.

SLEEVE OR BALL BEARING. These motors are furnished with quiet running steel-backed babbitt-lined sleeve bearings of high load carrying capacity. Ball bearings can be supplied when desired.

NEOPRENE CUSHIONING RING. Annular mountings, of oil-resistant neoprene, bonded to steel rings, cushion the motor in its cradle base to provide ultra-quiet operation.

Wagner Electric Corporation
6413 PLYMOUTH AVENUE, ST. LOUIS 33, MO., U.S.A.
Manufacturers of LOCKHEED® Products

CRESCENT

INTERLOCKED ARMOR POWER CABLE

GIVES YOU *SPEED and* ECONOMY OF INSTALLATION

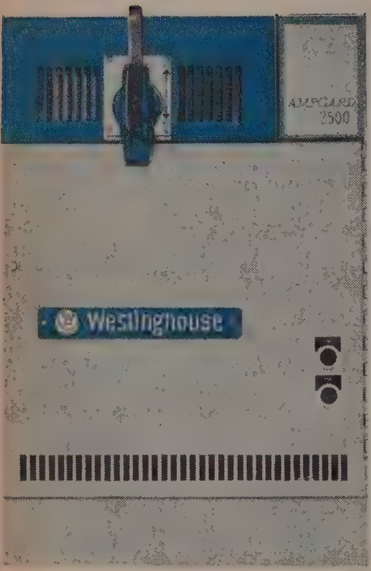
Crescent Interlocked Armor Cable with ALUMINUM or GALVANIZED STEEL ARMOR provides a flexible metal-enclosed method of wiring for power. Speed and economy of installation are the principal advantages of these cables since they can be placed on easily hung racks or attached to building surfaces. Maximum current carrying capacity is secured by the use of the varnished cambric insulation. For outdoor or damp location installation, it is furnished with SYNTHOL IMPERVIOUS SHEATH between the insulated conductors and armor, as illustrated above.

The Varnished Cambric insulated conductors are thoroughly protected by the Impervious Sheath of tough thermoplastic which is highly resistant to moisture, alkalies, acids and oils. This cable shows attractive savings when strung from messenger cables or in troughs outdoors or between buildings.

Crescent Interlocked Armor Cable also available with butyl rubber insulation.

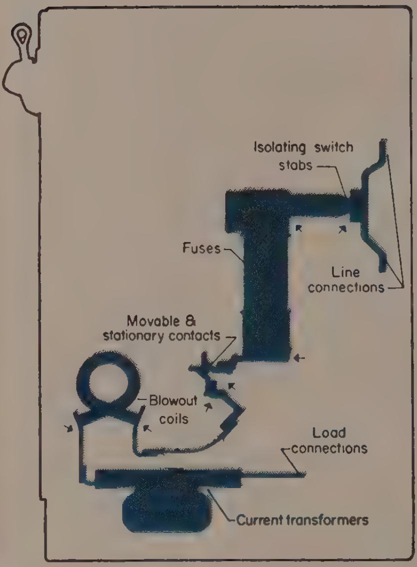
CRESCENT INSULATED WIRE & CABLE CO., INC.

TRENTON, NEW JERSEY



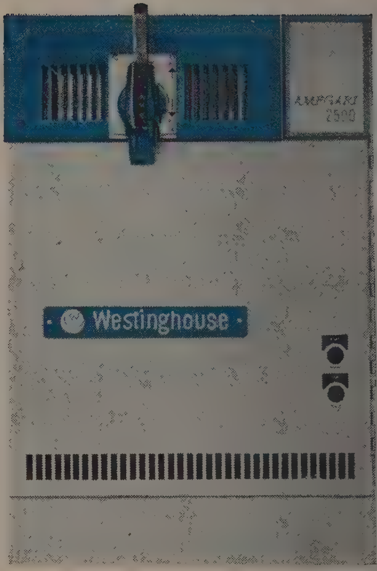
Ampgard® 2500

A new design concept in starters to match all of your 2300-volt motors.



Most Advanced Design

Component-to-component connections reduce current-carrying junctions 50%, eliminate internal bus and cable, and reduce heating.



Lowest Initial Cost

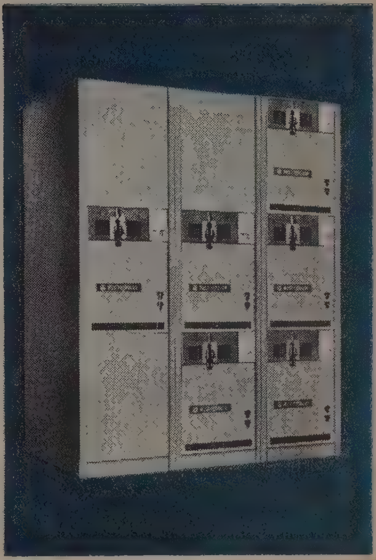
Saves as much as 20% over old-type conventional higher voltage starters. Lowest cost 2500-volt motor-starter on the market to own and operate.

Safest to Operate

Complete system of six interlocks, nine other safety features protect your personnel and equipment.

Quickest to Install and Maintain

Comes completely assembled. Easy two-man installation. All major components are modular-drawouts, front-accessible for quick inspection. Overhaul requires only 45 minutes.



Most Compact

One, two or three units can be stacked in a single 90″ high enclosure for compact floor mounting. Arranged this way, they occupy only 5.4 square feet of floor space ... much less than other starters. With low voltage starters added, they form a centralized motor control center.

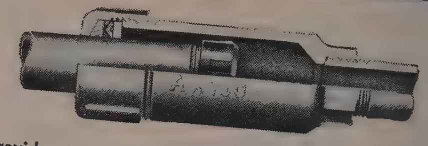
See the Ampgard 2500. Your Westinghouse sales engineer has all the facts and will gladly give you a complete product feature demonstration. Or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. *You can be sure . . . if it's Westinghouse.*

J-25016

Westinghouse

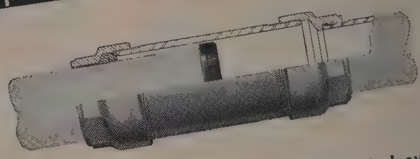
in the long run... it's O.Z.

Type AX



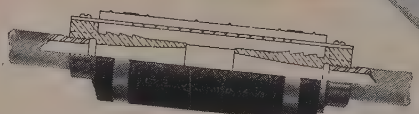
Provides 4″ expansion, contraction movement. Malleable iron head, body Hot Dip Galvanized. Weatherproof head sealed by factory-installed high grade graphite packing. Insulating conduit end bushing eliminates cable abrasion. 10 sizes for conduit ½″ to 4″ diameters.

Type EX



Permits 8″ conduit movement. Optional length sleeves, additional cost. Weatherproof head sealed by factory-installed high grade graphite packing. Insulating bushings prevent cable abrasion. Hot Dip Galvanized finish. 12 sizes for ½″ to 6″ conduit diameters.

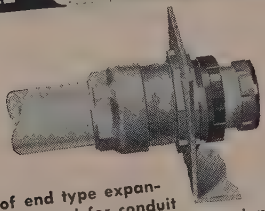
Type DX



Patented

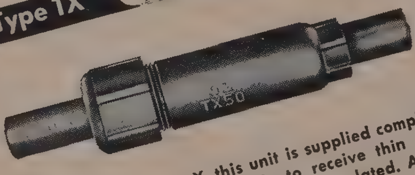
Compensates for deflection, expansion, contraction. ¾″ movement all directions from normal; 30° angular movement. Also used as vibration damper between conduit sections. 10 sizes. Watertight (NEMA 4) and submersible under 25 ft. head of water.

Type EXE



Weatherproof end type expansion fitting. Designed for conduit terminating in junction box, where expansion, contraction take place. Supplied complete: locknuts, bushings. Standard finish, Hot Dip Galvanized. 12 sizes.

Type TX



Similar to the Type AX, this unit is supplied complete with extension nipples, ready to receive thin wall couplings. Standard finish is cadmium plated. Available in 6 sizes for conduit ranging from ½″ to 2″.

for the longer line of EXPANSION FITTINGS

In the long run, no line of conduit is more dependable than its components. When it comes to dependability in expansion fittings, look to O. Z. as the line that measures up! Five basic types provide the dependable answer to your fitting problems in conduit expansion, contraction, and deflection. O. Z. is the dependable line because it's the line with the *right size*, the *right type*, for every requirement! Types AX, DX, EX and EXE available in aluminum at no extra cost.

O.Z. ELECTRICAL MANUFACTURING CO., INC.

262 BOND STREET • BROOKLYN 17, N. Y.

- CAST IRON BOXES
- CABLE TERMINATORS
- POWER CONNECTORS
- SOLDERLESS CONNECTORS
- GROUNDING DEVICES
- CONDUIT FITTINGS
- INTERLOCKED ARMOR CABLE FITTINGS

Sales Office and Warehouse: 406 So. Cicero Avenue, Chicago 44, Ill. • ESterbrook 9-0326
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VANCE In-warranty Labor Insuranc
compensates for normal ballast replacement labor cost

ADVANCE IN-WARRANTY
ILI
ADVANCE TRANSFORMER CO.
LABOR INSURANCE

ADVANCE IN-WARRANTY

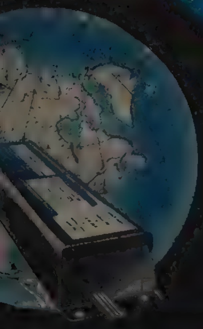
The ADVANCE TRANSFORMER CO. **ILI** (In-warranty Labor Insurance) Program is designed to reimburse the Electrical Contractor for normal labor costs incurred in replacing ADVANCE In-warranty High Power Factor Fluorescent Lamp Ballasts.

ILI permits the Contractor to guarantee both labor and ballasts in fluorescent lighting installations. It gives fast and more efficient service for lighting equipment manufacturers' products if an ADVANCE Ballast becomes inoperative within the two-year warranty period.

The results of a recently conducted survey among NECA contractors were taken into consideration in the development of this program. The NECA members were sent a letter and questionnaire to determine an equitable cost for changing out inoperative Fluorescent Lamp Ballasts. The answers received varied, however, ADVANCE TRANSFORMER CO. took these variables into consideration to arrive at an average amount to be paid the contractor for changing out each in-warranty ADVANCE Fluorescent Lamp Ballast.

Remember, **ILI** is an exclusive program of ADVANCE TRANSFORMER CO. who brought the lighting industry Kool Koil Fluorescent Lamp Ballasts, ADVAN-guard, Thermally Protected Fluorescent Lamp Ballasts, Visa-Volt Color Coding, a Nation-Wide Service-Stocking Distributor Program and other important developments to meet the industry's changing needs.

LABOR INSURANCE



Write today for complete literature on this ADVANCE In-warranty Labor Insurance ILI Program, another revolutionary benefit from the World's Largest Exclusive Manufacturer of Fluorescent Lamp Ballasts.

"The Heart of the Lighting Industry"®

ADVANCE®

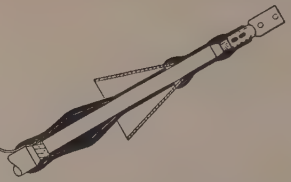
WORLD'S LARGEST EXCLUSIVE MANUFACTURER OF

TRANSFORM

Do you know which one tape can be used for . .

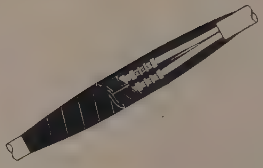
Insulating

and jacketing spacer-type aerial cables?



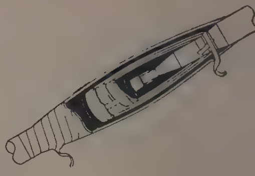
Terminating

polyethylene or rubber insulated power cables?



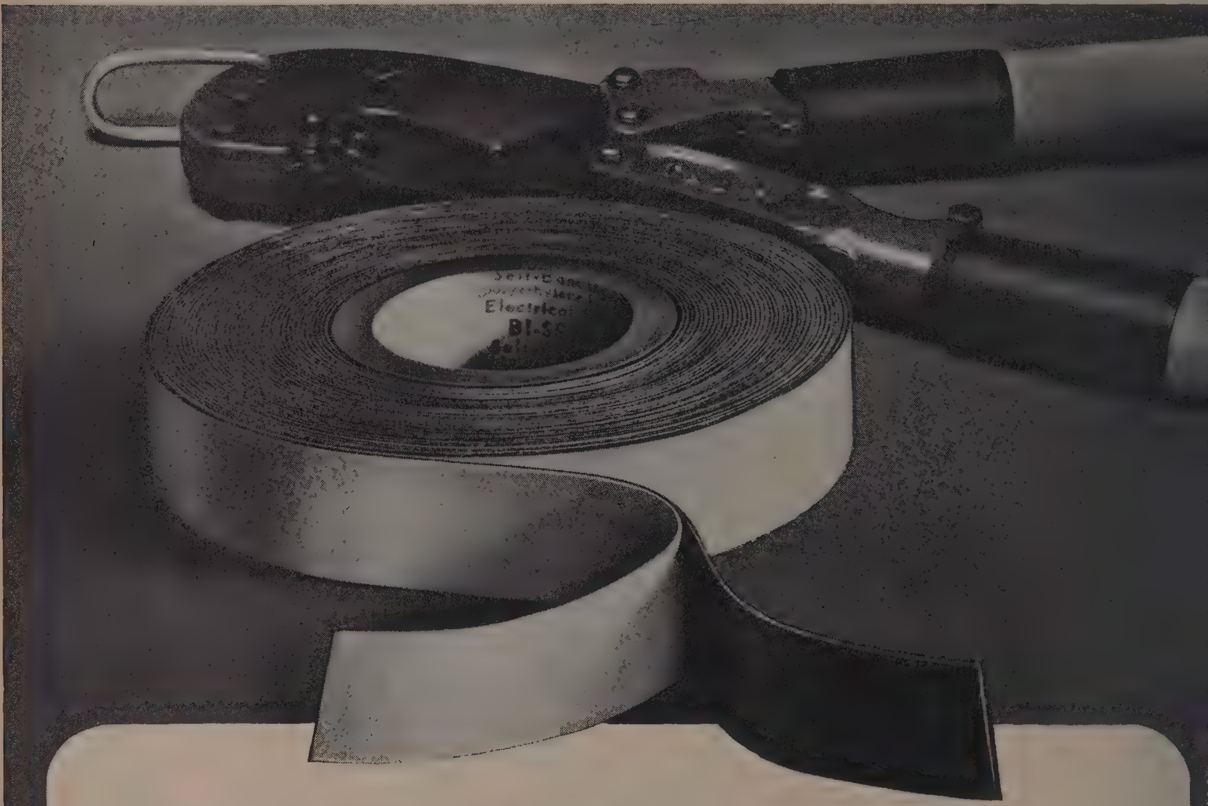
Sealing

service entrance connections and telephone drop wire splices?



Splicing

polyethylene or rubber insulated power cables?



Only BI-SEAL does all four!

SELF-BONDING ELECTRICAL TAPE

Because Bishop BI-SEAL Type 2A is *chemically cross-linked* and *polyethylene based,* it is compatible with both rubber and polyethylene wire and cable insulation. In addition, its unique self-bonding action, toughness and unmatched resistance to aging has established it as the standard multi-purpose electrical insulating tape. Check the outstanding properties of BI-SEAL. Write today for engineering data.

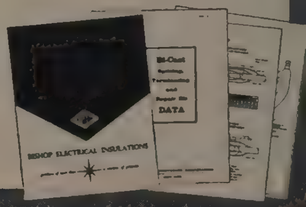
Send for our fully-illustrated catalog. It includes a brochure describing the new Bi-Cast epoxy-wrap method for simplified splicing, terminating and repairing of paper-lead cable.

- **Superior corona and ozone resistance**
- **Excellent moisture, corrosion and chemical resistance**
- **High dielectric strength, low power factor**
- **Exceptional temperature, aging, weathering characteristics**
- **Long storage life**

BISHOP

Manufacturing Corporation Cedar Grove, Essex County, N. J.

Sales representatives located throughout the world



COMPRESSION TOOL COURTESY THOMAS & BETTS CO., INC.

The four basic frame sizes of General Electric molded case circuit breakers cover every need from 15 to 1000 amperes.

Not five or more frames, not a variety of sizes up to 22 inches (G.E.'s maximum is 15½ inches). Just four sizes that make your job of circuit breaker selection easy and simple.

This is the line-up:

E 100 line — 15 to 100 amperes, 240 and 480 and 600 volts
F 225 line — 70 to 225 amperes, 240, 480 and 600 volts
J 400 line — 125 to 400 amperes, 240, 480 and 600 volts
K 1000 line — 125 to 1000 amperes, 240, 480 and 600 volts

There are no special sizes for special applications either. Hi-Break* models (Up to 75,000 ampere interrupting rating) and Vu-Break* models (visible contacts) have same frame dimensions.

New F 225 and J 400 lines feature ambient compensation to 50°C without complex derating...plus adjustable magnetic trip with ±10 percent tolerance at any setting. A full selection of accessories, too.

Easy to select, versatile, compact — all good reasons to standardize on General Electric circuit breakers. Write for bulletin GEA 7410. *Circuit Protective Devices Department, Plainville, Connecticut.* *Trade Mark

GENERAL ELECTRIC

Onan

Ask the man who owns an Onan why he didn't buy a cheap electric plant

The chances are the man who owns an Onan has *tried* a cheaper Plant. Most of our best customers have compared competitive brands.

There are several reasons why these users standardize on Onan.

They may have found that the "cheap" electric Plant actually costs as much as an Onan. Maybe more. They might have bought a stripped down Plant with an attractive "list." And then discovered that "price adders" for such essentials as oil pressure and water temperature gauges, radio suppression—even mufflers!—brought the actual price of a ready-for-work "bargain" above Onan's fully-equipped cost.

Or, the user who tried another make and then standardized on Onan might have kept downtime and maintenance records, and figured his costs on original expense plus upkeep over a year's time. Standard Onan features such as Stellite valves gives up to three times the valve life. *Onan's new J-Line, with Overhead Valve design, operate twice as long as L-head engines without lead deposits build-up. Give up to 15% more power and cut fuel consumption 10%, too.*

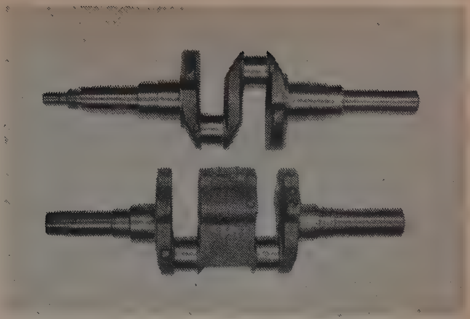
Dependability might have made the difference. Onan units are built-up to performance, never down to a price. *Every* Onan Plant is run-in and tested under full load for several hours. Other manufacturers spot check—for minutes.

There are lots of other good reasons why Onan is the World's Leader. Factory trained franchised distributors, local parts and service, one-source responsibility . . .

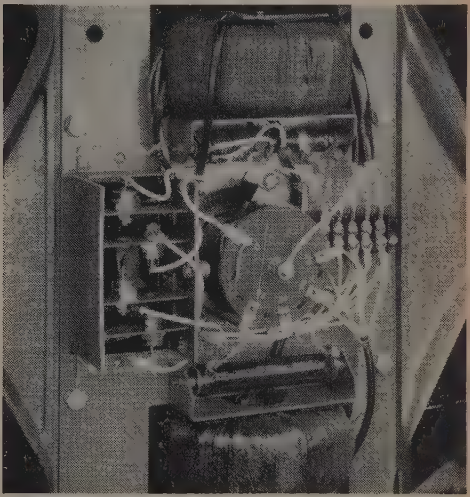
When you're in the market for an Electric Plant, why don't you talk to a man who owns an Onan? He's the most objective person *you* can talk to . . . He's one of *our* best advertisements!

Onan

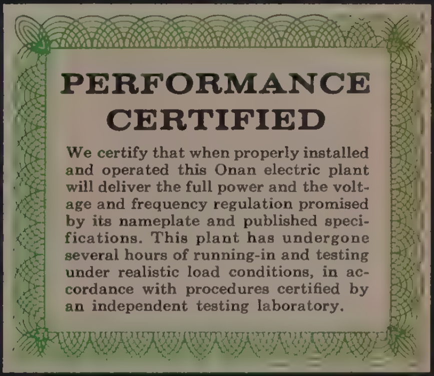
ONAN Division, Studebaker-Packard Corp.
2570 University Ave. S.E., Minneapolis, Minn.



Onan's bigger, stronger crankshaft, compared to typical competitive part, typifies the extra ruggedness Onan builds into all Electric Plants.

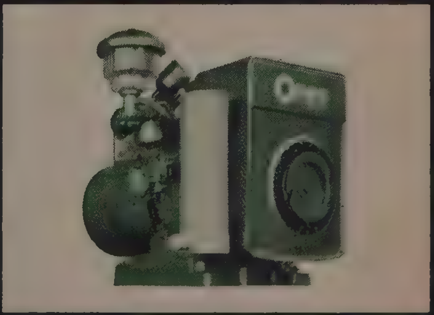


Onan's exclusive Magneciter generator is static excited to eliminate rotating exciter and mechanical regulator. Moving parts are eliminated in *both* exciter and regulator. Voltage recovery is five times faster than brushless type generators.



PERFORMANCE CERTIFIED

We certify that when properly installed and operated this Onan electric plant will deliver the full power and the voltage and frequency regulation promised by its nameplate and published specifications. This plant has undergone several hours of running-in and testing under realistic load conditions, in accordance with procedures certified by an independent testing laboratory.



WHO uses Champion Lamps?

Champion Lamps provide high-level illumination in Raytheon's Wayland, Mass., laboratory drafting room (top); Spencer Laboratory at Burlington, Mass., (center); and Wayland machine shop.

RAYTHEON

uses Champion Lamps

You can judge the quality of Champion Lamps by the calibre of the companies that buy them.

Raytheon, for instance.

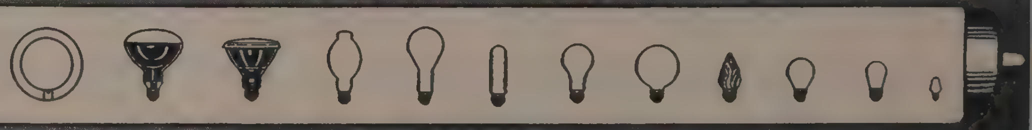
One way that Raytheon maintains its own world-wide reputation for excellence is by demanding a high degree of excellence in the equipment it purchases for plant operations. If Champion Lamps didn't meet severe quality standards, thousands of them would not be illuminating Raytheon's plants and laboratories.

Specialists in Industrial Lighting Since 1900

CHAMPION LAMPS

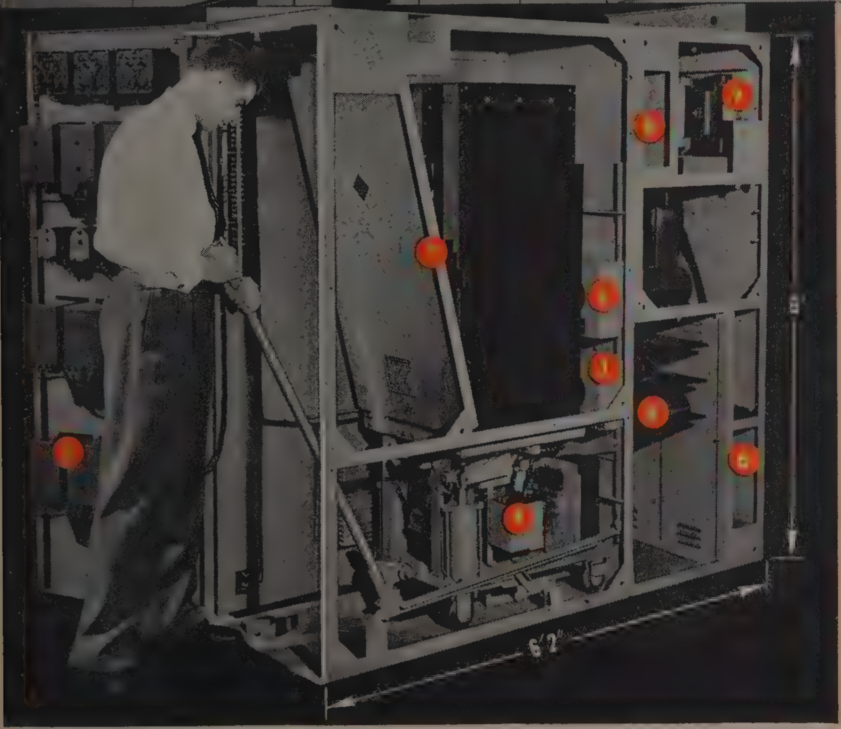
Lynnway, Lynn, Mass. Lynn 3-2000

CHAMPION LAMPS



ALLIS-CHALMERS

▲ 4.16 kv metal-clad equipment serving a west coast city.



1. Separate compartments for current transformers.
2. Full panel metering and relaying.
3. Double-lock panel for operator safety.
4. Easy service accessibility without dismantling.
5. Glass polyester insulation throughout.
6. Separate up-feed and down-feed cable compartments.
7. Fully cast, trunnion-mounted potential transformers.

Lowest height, easiest access

the only switchgear with fully isolated current transformers

The front-accessible current transformers can be inspected, maintained or replaced without exposure to any high voltage compartment. A-C metal-clad units are just 72 inches high — means eye-level instrumentation . . . shoulder-height accessibility of component parts. And the entire panel can be used for meters and relays. Maximum compartmentation and dead-front construction offer greater safety. Buswork and components arranged for easy addition of future units.

You get rapid, one-stroke insertion of the circuit breaker. The breaker has glass polyester insulation for highest impulse strength . . . the only self-locking protective barrier . . . four-bar linkage is mechanically, electrically trip-free. Primary disconnect fingers eliminate use of garter springs, and are on the circuit breaker for easy inspection. Both stored energy and solenoid operators are available. *For more switchgear information contact your nearby* **Allis-Chalmers** *office.* A-1457

How to select a Remote Control Switch

Electrical engineers are increasingly incorporating Remote Control Switches into their wiring layouts and circuits. Remotes today are used not only for the instantaneous control of emergency equipment, where they are a *must*, but for safety, economy and convenience wherever light or power is being distributed over a wide area.

Selection of Type

The selection of the right remote for a particular application must be given some study, but basically there are only two factors which affect the selection of type: (1) the class of load: non-inductive, such as heaters and lighting; or inductive, such as motors; (2) the voltages of the systems used.

Mixed Loads

Where there are mixed loads, non-inductive load rating must not be less than the combined full-load currents nor less than 66⅔% of the maximum current to be interrupted.

Any connected motors should be evaluated on the basis of stalled rotor current, using the multiplier of six times motor current if the actual value is not known. These currents added to the non-inductive load current will establish the maximum current which the switch will have to interrupt. In specifying the switch capacity, give class of the load and the amount of the load which is to be controlled.

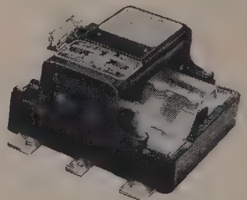
Why Mechanically Held

Another important selection-factor is that the remote control switch be mechanically held. Because it is essentially a feeder disconnect, the remote must be unaffected by line voltage conditions and respond only to control of the push buttons. ASCO mechanically held remotes insure against outages on vital circuits caused by momentary line voltage dips.

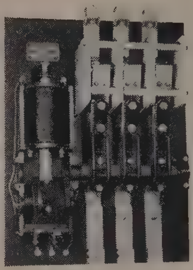
A detailed report on the advantages of ASCO remote control switches can be obtained by writing for new catalog 57-S2.

A selection of basic Remote Control Switches by ASCO

For Economy and Rugged Construction . . .



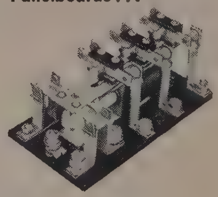
Use the Bulletin 920 — Up to 3 Poles, Single Throw, 30-75 Amps D-C, 30-200 Amps A-C. U.L. Approved to 600V A-C, 250V D-C. Recommended for all loads within its capacity range.



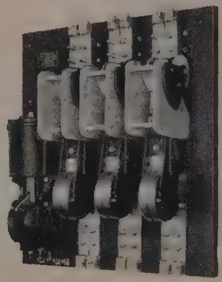
For Load Requirements Exceeding Capacity of the Bulletin 920 . . .

Use the Bulletin 910—Up to 4 Poles, Single Throw, 30-400 Amps, 250 volts, A-C.

For Small Panelboards . . .



Use the Bulletin 909 — Up to 5 Poles, Single Throw, 3 Poles, Double Throw, 30 Amps, 250 volts, A-C or D-C.

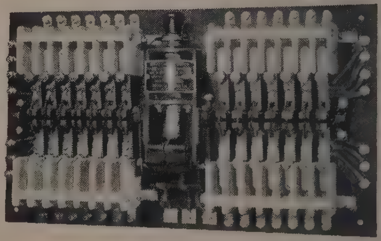


For High Capacity, Highly Inductive Loads . . .

Use the Bulletin 911—Up to 4 Poles, Single Throw, 30-1000 Amps, 600 volts, A-C, 250 volts, D-C.

For Multiple Pole Requirements . . .

Use the Bulletin 915—Up to 24 Poles, Single or Double Throw, 30, 60 and 100 Amps, A-C.



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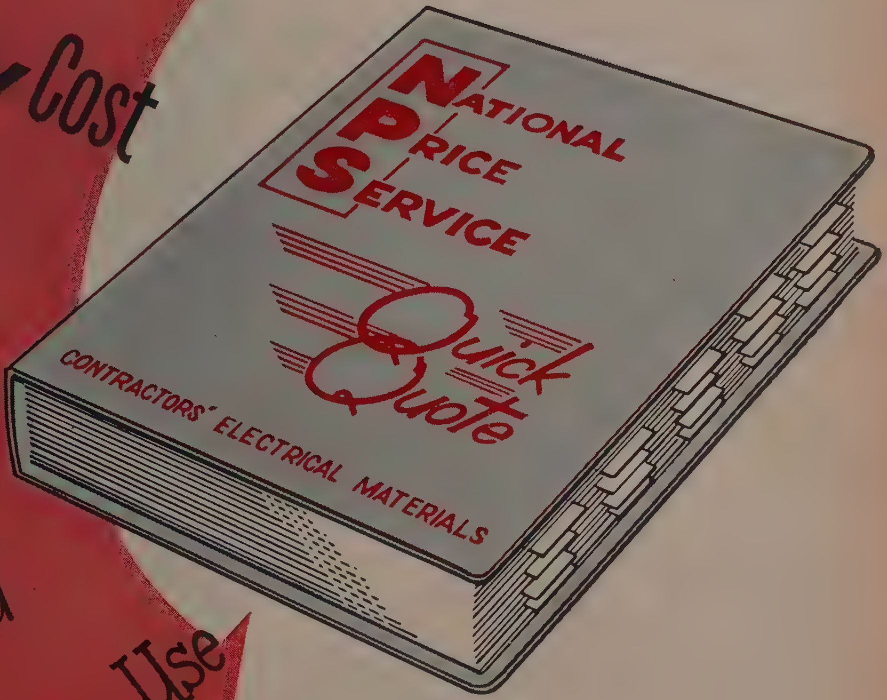

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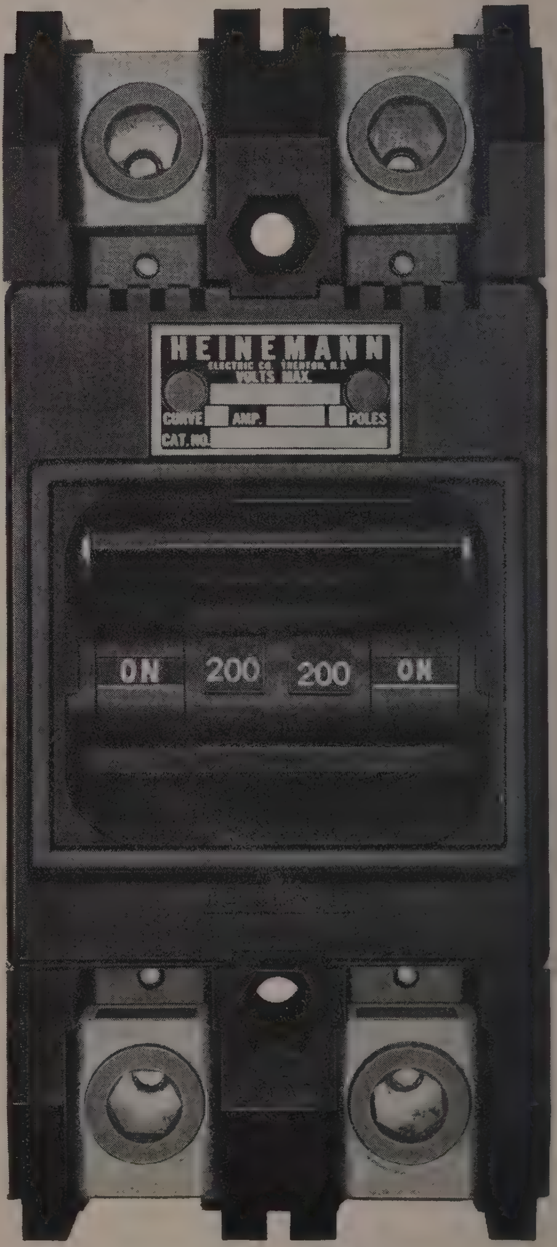

Shown here, actual size, is Heinemann's SE-33 circuit breaker. It's about half the size of any other breaker that can be used for 200-amp service. • In a panelboard, it saves several inches. In its own enclosure (indoor or outdoor), it's more compact than equivalent fused safety switches or service-entrance pullouts. The SE-33 is the only 200-amp breaker built on a 200-amp frame (others use a 225-amp frame). This makes it smaller. And less expensive. It's also easy to install. Its terminals accept copper or aluminum conductors in the range of #6—#250, CM CU/AL. It has pressure-type solderless connectors. • The SE-33 is a two-pole breaker, available in ratings of 125, 150, 175, and 200 amperes, 120/240 V, AC. It always carries full-rated current because it's magnetically actuated. It never has to be derated for high ambient temperatures. All the details are in Bulletin 1003. We'll be glad to send you a copy.

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TO BRING IDEAS, NEWS AND HELPFUL INFORMATION TO ELECTRICAL MEN

63rd YEAR

MAY 1962

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CODE COMMENTS .... FIRST PAGE
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PRACTICAL TIPS .... FOURTH PAGE
ENGINEERED SPECIALS .... FOURTH PAGE

Surface Systems Proved Best for School Rewiring

Raceways and multi-outlet systems provide rapid installation, economy and flexibility

Traditionally, as soon as school's out, the contractors are in — to modernize and refurbish the plant in preparation for next year.

More and more, modernization of the electrical system is an important part of the school's program. This is necessitated by the tremendous increase in electrical usage required by today's teaching techniques.

With the current emphasis on science, more laboratories are needed, and much of the laboratory equipment requires electricity. To speed the teaching of languages, many schools are installing electronic teaching aids. And audio-visual aids are commonplace at all levels.

Most school rewiring jobs fall into two major categories: to provide more and better lighting, and to provide additional power.

In addition to the use of surface raceway systems for general lighting installations, these systems are recognized as an effective method of installing emergency lighting sys-

continued on third page

SCHOOL laboratories require a good deal of electric power. Conveniently located receptacles make it easier for student to use modern instruments.

Code Comments

Raceway Mounting Clips

Q. *Do I have to use a mounting clip every five feet in a raceway? Can I let the boxes hold it if I have a box every six or seven feet?*

A. In general the Code requires that electrical equipment shall be installed in a neat and workmanlike manner and securely fastened in place. The outlet boxes usually provide sufficient anchorage for medium length runs of raceway. On longer lengths, clips, couplings, or straps should be used. See Article 110-11, 300-11, and 352-2.

Residential Outlets

Q. *How many outlets can I put on a residential circuit?*

A. In residential installations the number of outlets on a circuit is not limited but it's always good practice to separate circuits so that the blowing of one fuse will not put an entire area out of commission. Where possible, it is desirable to have at least two circuits in each room, although this is not required specifically by the Code.

Permissible Load

Q. *What is the permissible load for a branch circuit having two or more outlets?*

A. In general a branch circuit is limited by the size of the fuse permitted. The fuse is limited by the size of the wire permitted. Beyond this, no one portable appliance shall exceed 80% of the branch circuit rating and a total rating of fixed appliances shall not exceed 50%. See Section 210-24 of the Code.

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Editorial

The contractor and schools

The contractor — like all Americans — has a vital stake in the school system of this country.

With the school modernization program just ahead, the electrician should remember that in bidding and servicing a school job he owes it to the community to see to it that the school gets the best dollar value — in terms of both material and labor.

Another thing about school jobs: because of the traffic in and out of the building, school work can be a showcase for the contractor. A neat, workmanlike job enhances his reputation; sloppy installations mark him down.

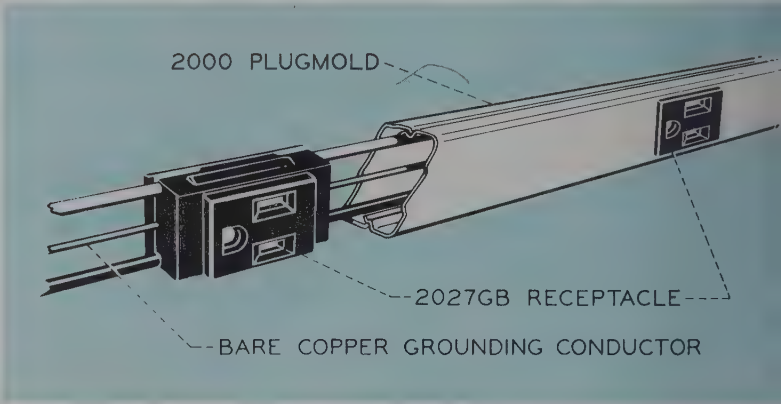
And surface systems provide a good way for the contractor to put his best foot forward.

Product of the Mont

GB series provide continuous equipment grou

For use with the Plugmold 2000 and 2200 series, respectively, the 20GB and 22GB Snapicoil® provides a continuous equipment grounding copper conductor throughout.

This 3-wire grounding system provides an effective low resistan path for stray or faulty currents a necessary requirement for delica electronic testing benches. For normal grounding, the 20G and 22 series are fully adequate.



Quiz Corner

Questions for this department are taken from inquiries received from the field. Your questions are welcome; indeed, they are necessary if this department is to serve you with worthwhile information. Address:

Quiz Corner
The Wiremold Company
Hartford 10, Conn.

Q. *Is 2000 Plugmold available with a duplex grounding receptacle?*

A. No. We suggest using the single grounding receptacles more closely spaced. For example, where duplex receptacles on 60″ centers are desired, use grounding receptacles on 30″ centers. Plugmold 2000 is now available with single grounding receptacles on 6″, 9″, 12″, 18″, 30″, and 60″ centers.

Q. *When suspending 2100 and 3000 Wiremold from ceiling to feed and support lighting fixtures, how close should the hangers be spaced?*

A. Every five feet.

Q. *In extending from an existing flush receptacle to Wiremold 500, I need a box deeper than the 5751. Is one available?*

A. Yes. Use the covers of any of the boxes listed as 574— in combination with the 5751 base.

Q. *May Wiremold be concealed?*

A. No, except that Plugmold multi-outlet systems may be plastered in or concealed on three sid only.

Q. *Is the W-30 wire connect listed by Underwriters' Labora ries?*

A. Yes, for use with either N 12 or No. 14 solid conductors.

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urface Systems for School Rewiring

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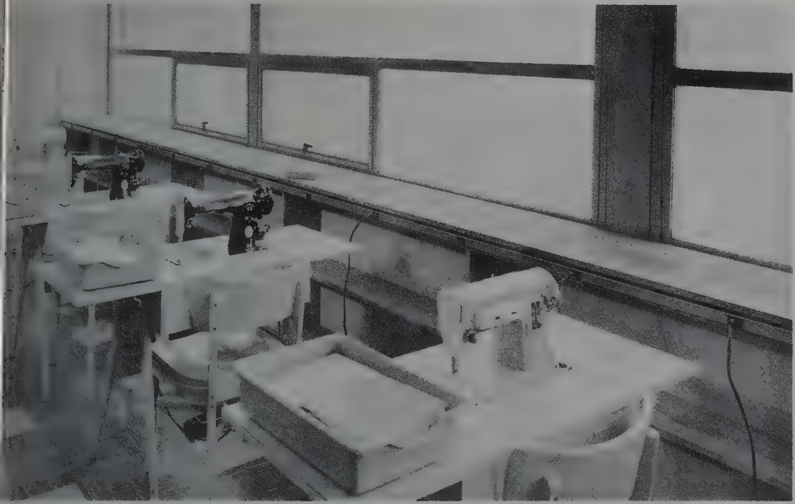

SEWING rooms are more efficient when outlets are located close to point of use. Plugmold also eliminates the hazard of dangling, unsightly wires.

BRICK walls posed no problems in adapting his area to a high school electrical shop. Plugmold 2100 was used for its capacity and to meet special requirements.

THREE sizes of Wiremold raceway were used to wire this modern southern school for lighting. Partitions replace walls for flexibility of room arrangement.

tems which are becoming mandatory in many communities. Other uses include the wiring of clock and program systems and the installation of various types of fire alarm systems.

Because school boards are faced with the need to install new equipment and modernize existing schools with a minimum of cost, surface metal raceways and multi-outlet systems have gained increasing favor. These surface-mounted systems speed up installation (time always seems too short in school modernization jobs) and significantly reduce the need for redecoration caused by breaking into walls.

To the school board, this means that an installation which provides flexibility for the future — as well as adequacy for today — can be made rapidly and economically.

To the contractor, it means a way to satisfy the school board's requirements, while it provides an opportunity to make a fair profit.

Engineers for a large Eastern university decided to standardize on Plugmold 3000 all through the structure. By using a single type of multi-outlet system, they reduced inventory, provided a capacity equal to any combination of electrical services that might be required, and assured themselves of flexibility for future needs.

Again, when a high school wanted to convert storage space to classrooms, surface metal raceways were selected to carry conductors for both power and lighting.

Wiremold 500 and 700 were chosen for the complete rewiring of a five-building complex that formed a junior high school. Engineers and contractors agreed that it would be hazardous to attempt in-wall wiring in the structures which averaged about 40 years of age. Instead, the old conductors were disconnected and left in the walls and a completely new distribution system installed.

Surface systems are also gaining increased popularity in new building where the use of solid construction techniques make it the only practical method of wiring.

WIREMOLD®

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Noteworthy

Personnel at Meetings

Between May 10 (when this issue appears) and June 10 (when the next one is due) our field and home office forces have no show commitments.

This doesn't mean they won't be out and around, though. Part of the Wiremold policy sends our people around the country, addressing various groups.

So, if your local group feels that a discussion by one of our men would be helpful, just ask your Wiremold representative. If he can't make it, he'll try to have an alternate on tap.

And while we're on the subject, if you're in the Hartford area, drop in — the welcome mat is always out to our friends.

Practical Tip

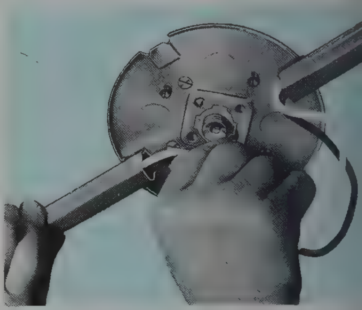
Conventional snaking techniques used for Wiremol

The techniques for wiring Wiremold one-piece raceway have been utilized by electrical contractors for many years. Wire is pulled or snaked through the raceway in the same manner as with conduit — without the inherent disadvantages of pipe cutting and threading.

This method eliminates the difficulty of holding conductors in place while the wire clips are located and snapped into position. Also, there is no danger of the weight of the wires pulling the clips or cover loose. In compliance with NEC recommendations, the entire raceway system is installed prior to wiring.

The one-piece raceway provides a virtually tamper-proof assembly that can be used as a complete sy tem from panel box to outlet, or modify an existing system.

Because of its design, the on piece raceway hugs the surfac However, when necessary, cover an base together are easily bent to co form to surface contours.



Engineered Special

Special Wiremold 3000 power strip for benche

PROBLEM:

To provide an electrical system which would adapt to a line of benches ranging from 6 to 18 feet, with overload protection for the power outlets on each bench, while permitting ease of rearrangement.

SOLUTION:

Strips of Wiremold 3000 were made up in three lengths and two types: a feeder and an extension strip.

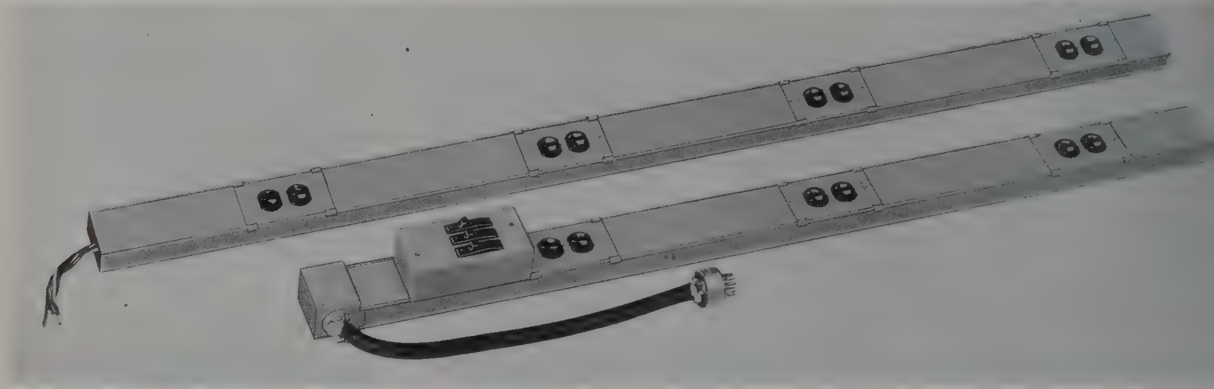
DISCUSSION:

After investigation, Wiremold engineers, in cooperation with customer engineers, selected Wiremold 3000 because of its ability to meet all the requirements at reasonable cost.

The feeder strips in the required lengths were designed as a 3-phase, 4-wire branch with a grounding conductor as a means for maintaining continuity of ground through the flexible non-metal cable.

The system was designed so tha one or more extension strips coul be connected to the feeder stri for wiring a line of benches. Th quick-disconnect, 5-prong plug ca provided the means for bench r arrangement.

For maximum safety, circuit pr tection was provided at each benc by equipping each feeder strip wi three single-pole circuit breake mounted in the 3000 base and usin a special 3046KD cover.



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ROME DELIVERS FAST Whether with two conductors or 37 conductors—or any number in between—these **standard** Rome control cables are often delivered right off the shelf. They're Rome CT cables: smaller, lighter, more flexible than rubber types, ideal for most control cable jobs. ■ Available quickly in No. 10 or No. 12 AWG, Type CT-B (AC or DC to 600 V) and Type CT-C (AC or DC to 1000 V) cables are insulated with polyethylene and jacketed with Synthinol*, assuring high dielectric strength and resistance to moisture, acids, alkalis, oils, heat, flame and mechanical abuse. You can install them in open air, ducts, conduit, tray or trough . . . or even bury them directly in the earth. Both types comply with the requirements of IPCEA-NEMA standards. ■ A 4-page booklet will give you all the facts: just write to Rome Cable Division of Alcoa, Dept. 7-52, Rome, New York.

*Registered trade mark for Rome's specially-formulated polyvinyl chloride.

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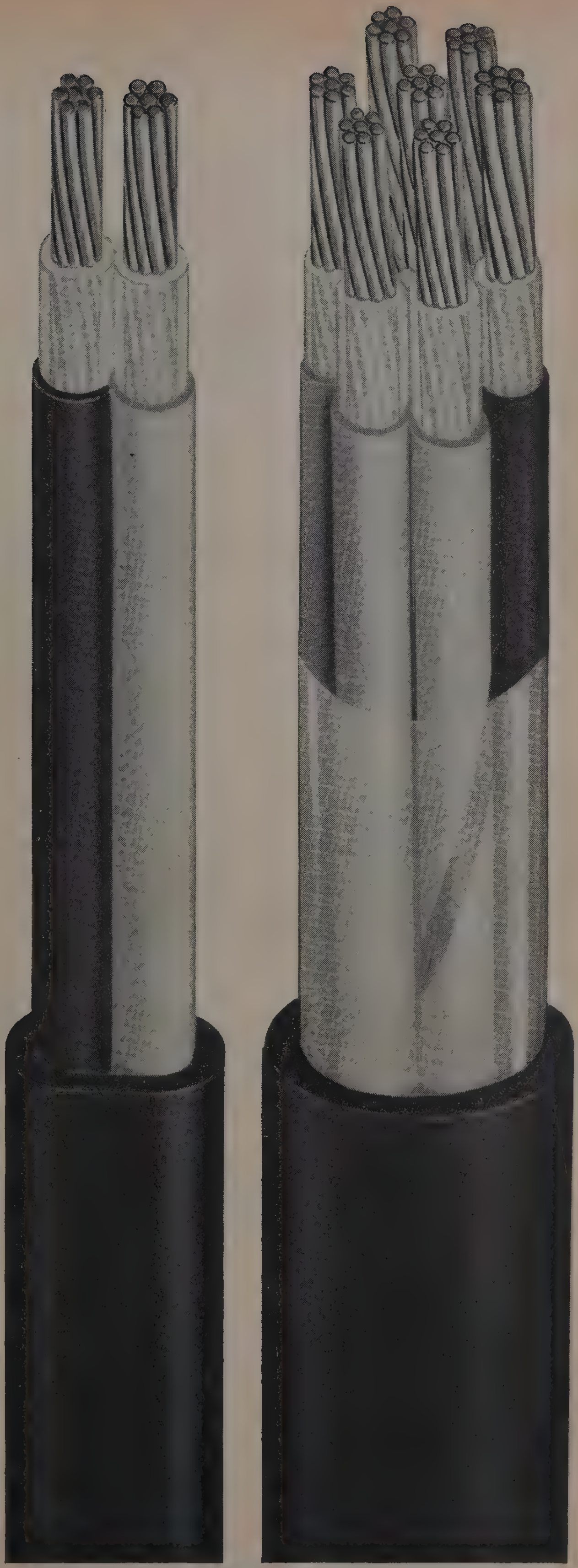
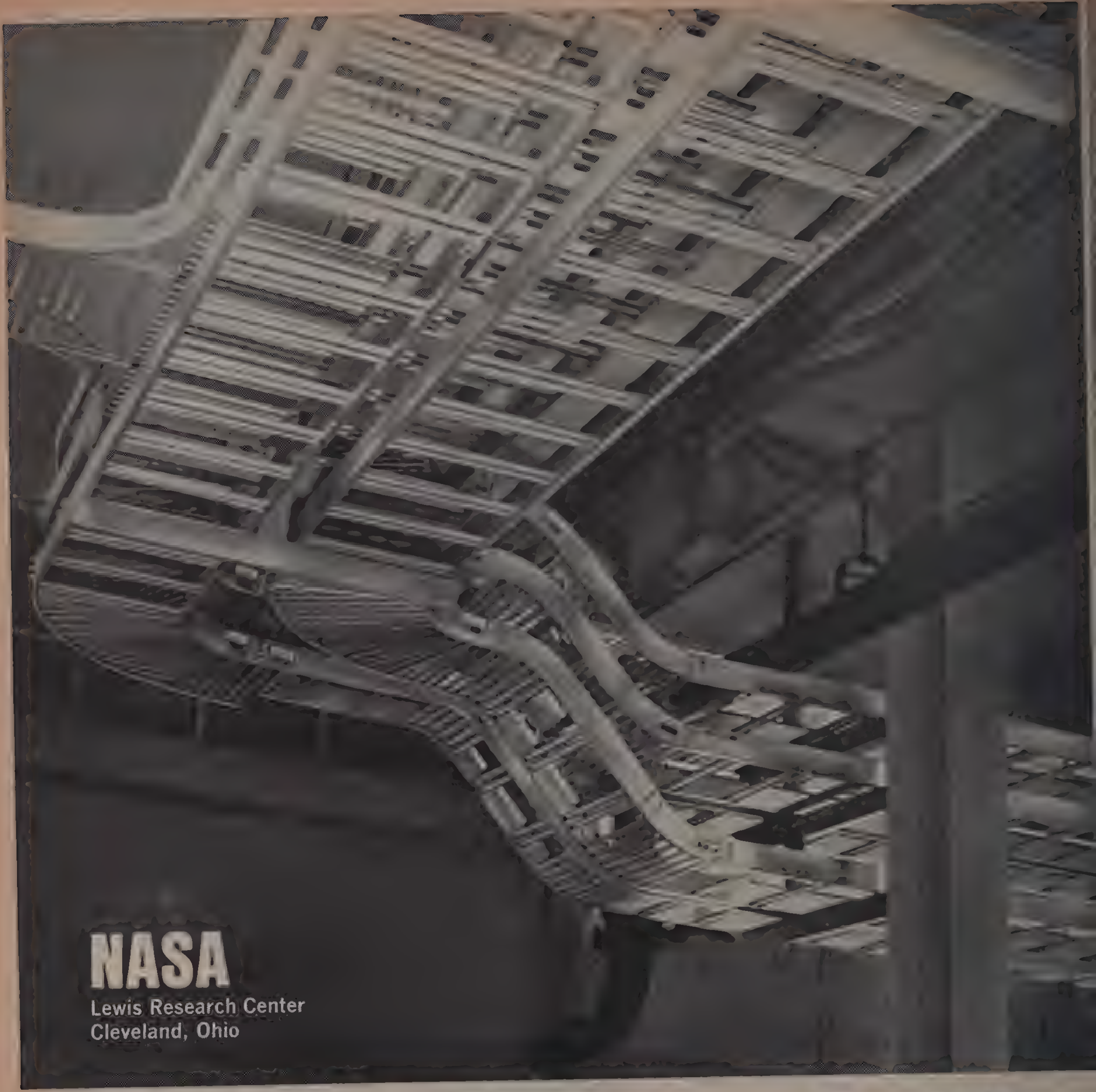


Two of Rome's standard control cables: two-conductor and seven-conductor #12 AWG 600-Volt Type CT-B.



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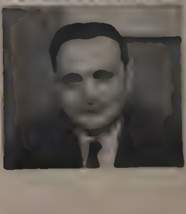
Low Installation Cost — made possible thru lightweight steel design and rapid QIKLOK™ splice.
Interchangeable—used with VENTRIB™ cable basket for maximum system flexibility.

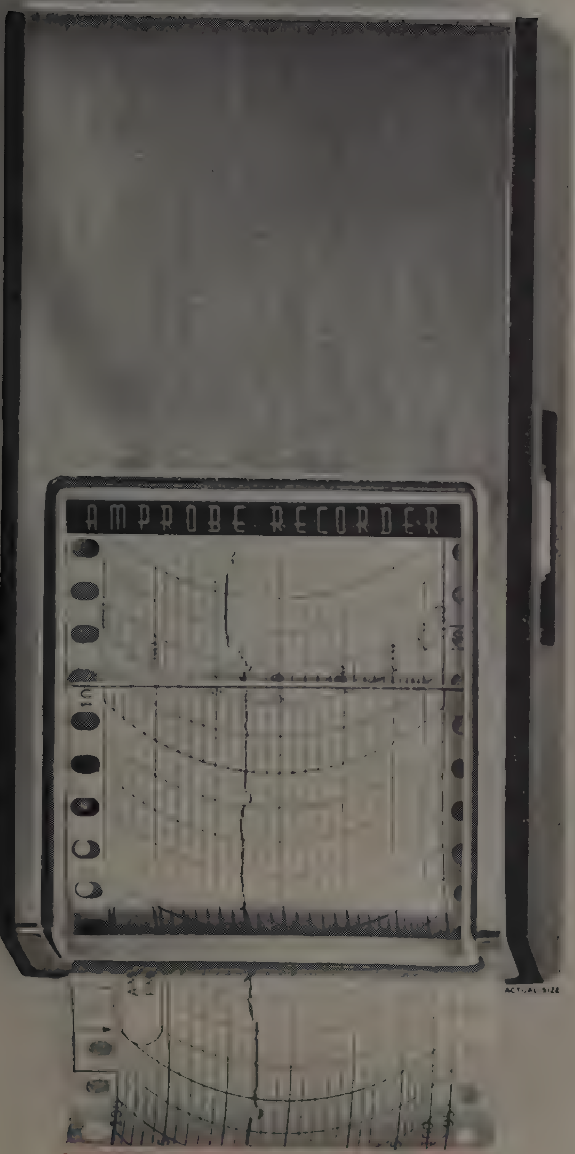
Lake Erie Electric, contractor on the NASA job, is completely satisfied with the new low-cost, ladder type VENTRAY™. The VENTRAY and VENTRIB in-stock parts made difficult changes of direction and elevation (shown above) and the entire installation a simple assembly operation.



Mr. Wm. M. Leblang, Vice President of Lake Erie Electric, Inc., Cleveland, Ohio—says: "We were pleased with ease of installation due to your lightweight steel design. Your competitive price, accurate take-off, installation drawings and prompt order service all contributed to an efficient labor saving installation."

See your local representative or electrical distributor or write Husky Products, Inc.

HUSKY DIVISION OF **BURNDY** 5300 VINE ST., CINCINNATI 17, OHIO



THIS RECORDING TAPE TROUBLESHOOTS FOR YOU 24 HOURS A DAY

The trouble with troubleshooting is that the electrical conditions which caused the difficulty often no longer exist when you get there. This usually develops into numerous, costly call-backs. But now, with the new, miniature Amprobe Recorder, you can obtain a continuous, permanent record of variations in voltage or current, as they happen, without the need for you to be present. The record is made automatically on a pressure-sensitive paper tape (no ink to spill or smudge) that loads easier than film into a camera. Without this chart in place, you can take direct meter readings. • The Recorder is rugged, completely portable and highly accurate. The expanded-scale voltmeter version, for example, records in two frequently used ranges (95-130 v AC and 190 260 v AC) to a tolerance of ±1 v. It sells for $84.85. Two clamp-on ammeters also are available: at $89.95 (ranges: 0 5 25 100 250 amps AC) and $94.85 (ranges: 0 10/50 250 500 amps AC). For complete details and specifications, see your Amprobe distributor or write today for a free catalog.

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SPANG Distributor: WESCO, Philadelphia

INSIDE THIS SHELL:

Top-quality wiring protection by SPANG® CONDUIT

This is the framework of Bell Telephone Company of Pennsylvania's new 20-story headquarters building in Philadelphia. And threading throughout this framework is a network of Armco's SPANG Hot-dipped Galvanized Steel Conduit, SPANGLEAM EMT and SPANG Rigid Aluminum Conduit to provide top-quality wiring protection.

In this $15,500,000 building project, SPANG conduit will carry wiring for lighting, fire alarms, control circuits and general power needs. Rigid conduit is used on vertical runs, while electrical metallic tubing is suspended above the finished ceilings.

SPANG Conduit and SPANGLEAM EMT, made by Armco, lived up to their fine reputations on this job: fast, on-time deliveries—easy cutting, bending and threading—trouble-free installation—good appearance in exposed locations.

If you're looking for a top-quality, uniform conduit for your next job, make it SPANG! And the best man to call for service is your nearby SPANG Distributor. For complete information, write *Armco Steel Corporation, Armco Division, Middletown, Ohio.*

Bell Telephone Company of Pennsylvania's new headquarters building in Philadelphia, to be known as Numbe
One Parkway, will be completed late in 1962. SPANG Conduit and EMT will protect wiring throughout the structur

ARMCO Armco Division

USE THE RS-3 AS A VOLTMETER to determine low or high-voltage conditions and to make all other commercial voltage tests. The rotary scale has 3 voltage ranges: 0-150/300/600 volts AC, and shows them only one at a time to eliminate chance of reading errors. Test leads supplied.

USE THE RS-3 AS AN AMMETER to balance circuits, set relays, take load surveys. The pointer lock lets you take accurate readings on the 5 current scales (0-5/15/40/100/300 amps AC), even when the conductor you're snapping around is hard to see.

USE THE RS-3 AS AN OHMMETER (attachment furnished) to check for continuity, opens and shorts, on a scale that reads 25 ohms mid-range. Only $52.50. At distributors everywhere.

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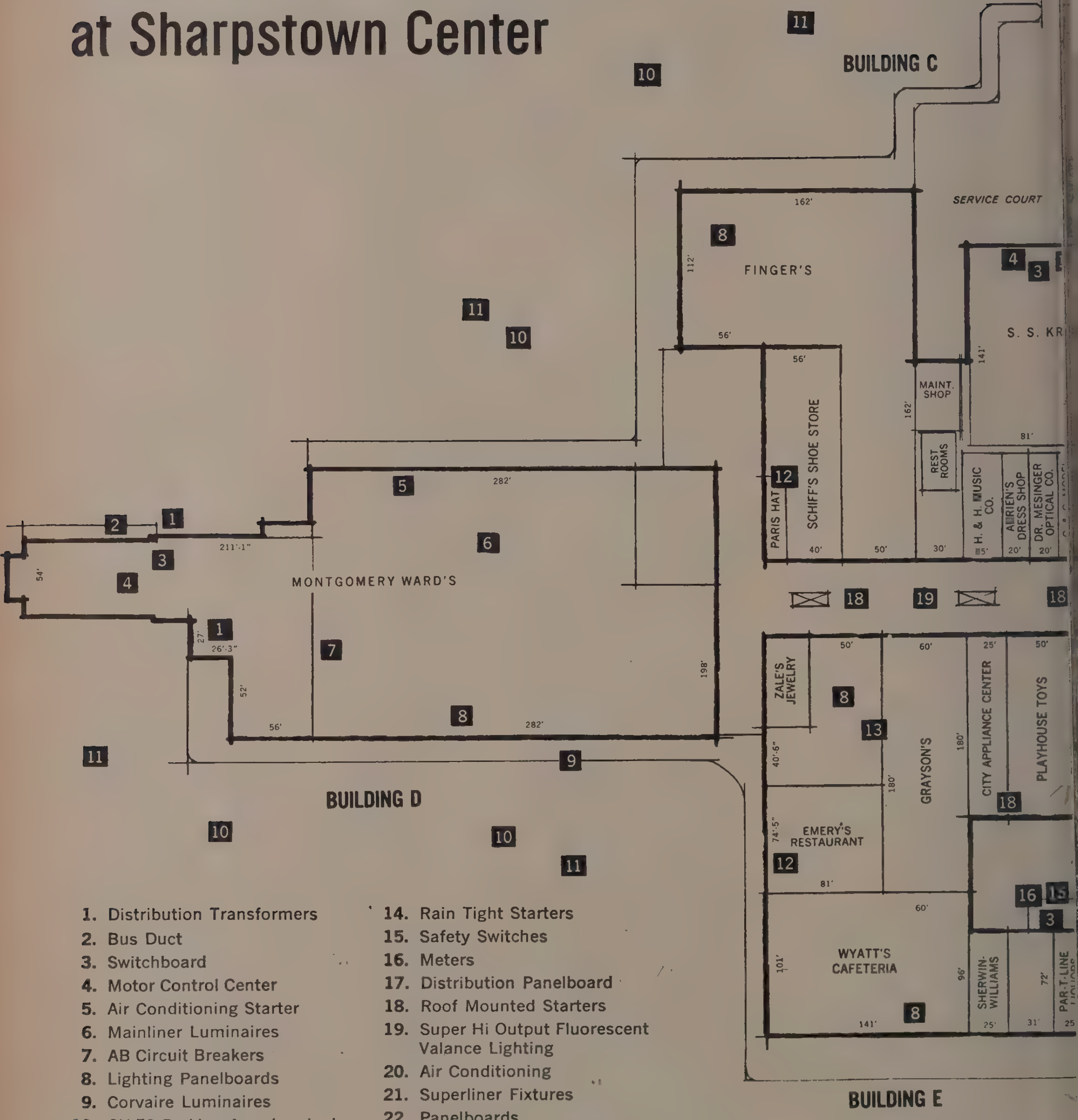
Westinghouse does a Texas-size electrical job at Sharpstown Center



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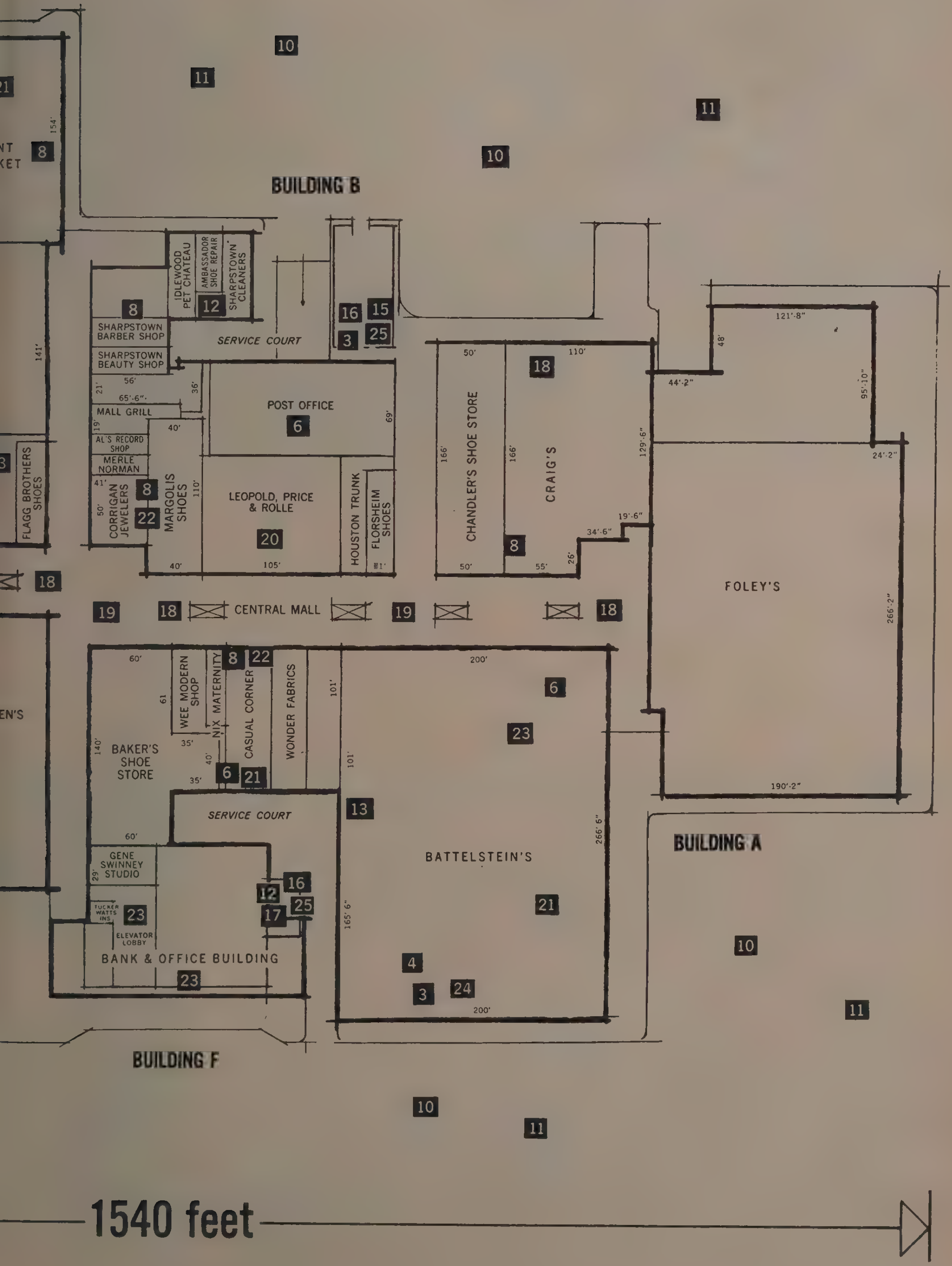
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50'
110'
166'
166'
129'-6"
19'-6"
34'-6"
26'
55'
121'-8"
48'
44'-2"
95'-10"
24'-2"
266'-2"
190'-2"
60'
61
140'
35'
40'
35'
60'
29'
101'
101'
200'
266'-6"
165'-6"
200'

J-94186-2

Owner: Sharpstown Realty, Houston • Architect: Sidney H. Morris, Chicago, Ill. • Associate Architect: Claude E. Hooton, Houston
Consulting Engineers: Bullock, Wright, & Miller, Inc., Houston • Electrical Contractor: Wert Sharp Electric Co., Houston
General Contractor: John C. Burns Construction Co., Houston • Westinghouse Distributor: WESCO, Houston

Westinghouse at Sharpstown Center (cont.)

Houston's new 750,000 sq. ft. Sharpstown Center looks to Westinghouse equipment to help accommodate 2 million customers—an estimated $75,000,000 market. Big, even for Texas, Sharpstown's 77 acres include 2 million sq. ft. parking area for 6,000 cars. It's on 261 overhead parking lights that the Westinghouse brand first meets and greets the shopping public.

The major construction problem was coordination of mechanical and electrical system requirements to give all stores the best merchandising environment possible. Westinghouse engineers and WESCO representatives from the Houston distribution outlet worked closely with the developer, consultants and contractor to meet tight dates, sometimes with overnight deliveries. The grand opening was on schedule, just three days after Hurricane Carla, in September, 1961.

Westinghouse, and its chain of distribution outlets, stands ready to help any shopping center project—be it a neighborhood strip or a $14 million Sharpstown. You get one-stop shopping, one source, one contact, one contract, one responsibility. Think about it for your next project. *You can be sure . . . if it's* Westinghouse

Foreground: Two of 261 OV-5 liners, an invitation in light car parking. Rugged OV-50 subjected to Hurricane Carla after installation without a unit failure.

Roof-mounted Life-line starte circuit breakers in weather-p closures control and protect conditioning motors.

sh trim of Ⓦ lighting panelboard nds with sales fixtures in Kresge's riety Store. AB de-ion circuit break- give positive protection, conven- t operation.

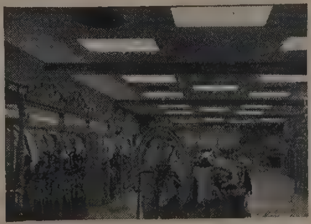
Two 40-ton Westinghouse air conditioning compressor-condenser units keep Bond's Clothing Store cool and comfortable for customer comfort.

Westinghouse Motor Control Center located in Battelstein's conveniently groups starter and breakers. Control Centers offer flexibility through modular and interchangeable units.

No annoying power hum for Flagg Shoe customers. Light weight DT-3 dry type transformers have extremely low sound levels—can be mounted almost anywhere.

wer supply by Ⓦ outdoor venti- ed copper bus duct carries full lding load—installs fast to help et construction deadlines.

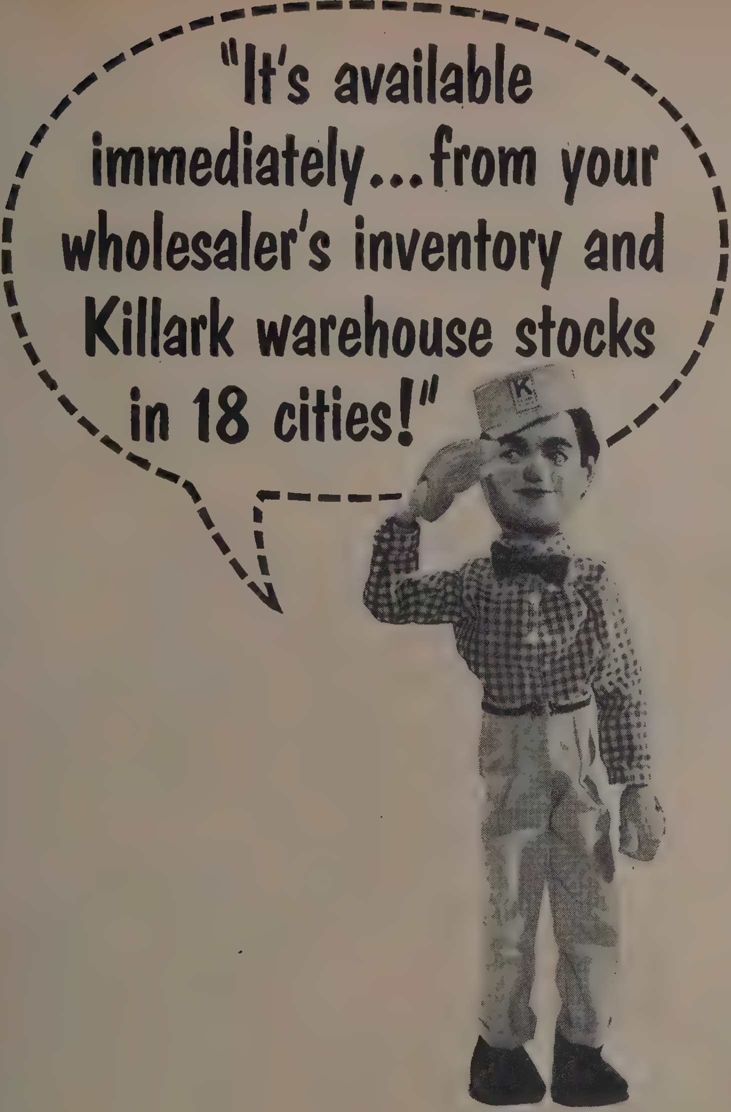
Three-lamp Superliner fixtures are economical, yet versatile. Ideal light supply for applications such as this Food Giant Supermarket.



Ⓦ Mainliner fluorescent luminaires bathe fashionable Casual Corner women's wear shop in 150 fc of diffused light—create quality atmosphere vital to tenant.

Construction team takes a coffee-break at Walgreens; R. E. Jordan, V.P., Sharpstown Realty; Jacque McCroskey, Ⓦ; W. C. Swain, WESCO; Wert Sharp, Electrical Contractor; Frank W. Sharp, Owner; Rex Bullock and George Wright, Consulting Engineers.

"How fast can it* be delivered?"


"It's available immediately...from your wholesaler's inventory and Killark warehouse stocks in 18 cities!"
K

Killark distributors can usually deliver all electrical fittings and fixture requirements from inventory. If not, your needs from the more than 7,500 items in the Killark line can be obtained *at once* from a convenient Killark warehouse. There are eighteen of these dependable supply sources located throughout the United States and Canada.

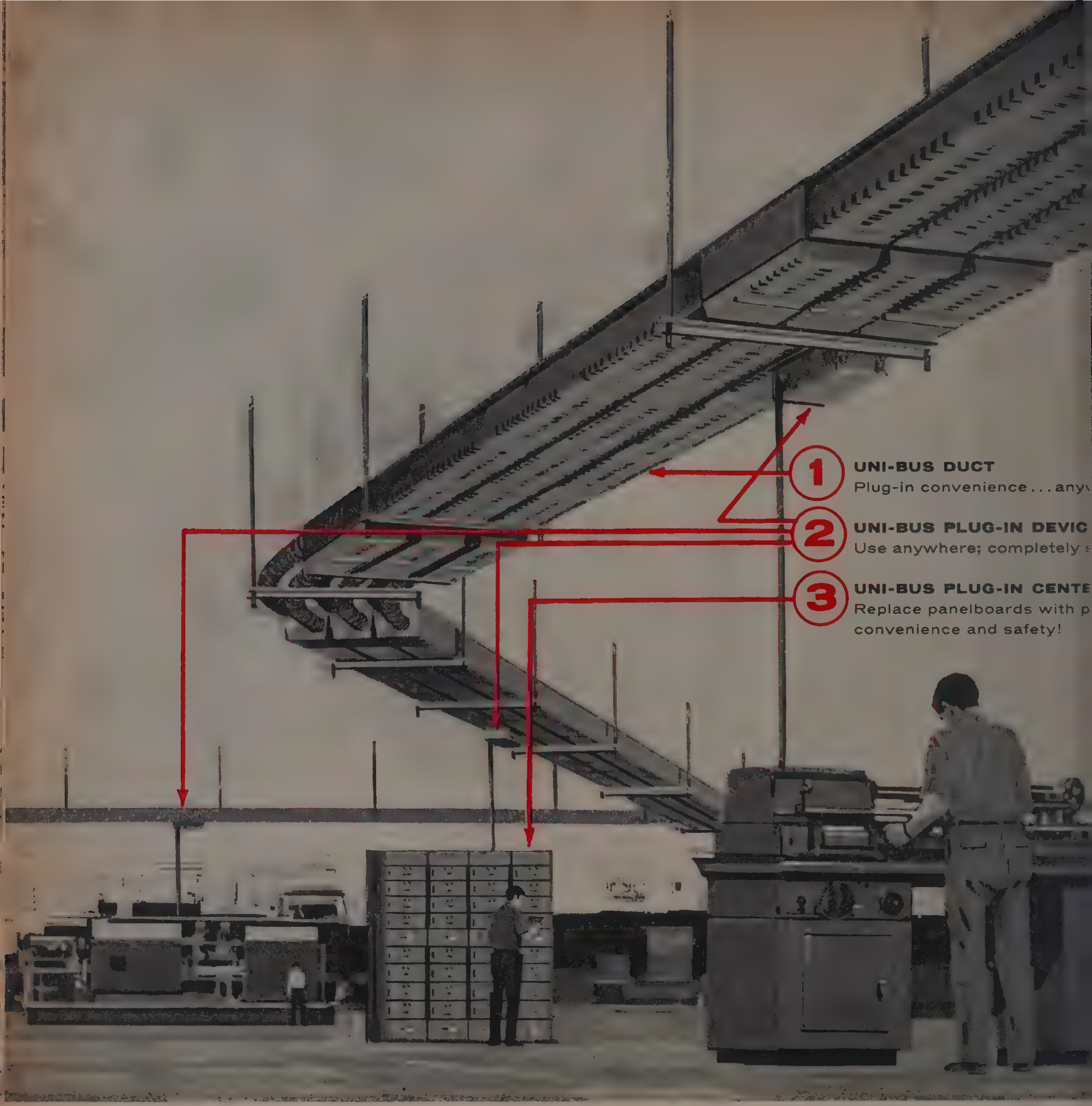
* KILLARK XALB-6 EXPLOSION-PROOF PULLING ELBOW . . . Copper-free aluminum casting, permanently rust-proof and corrosion resistant, non-magnetic and non-sparking. Split design provides easy access to wiring; ribbed for greater strength. Carried in stock for fast delivery, a typical example of Killark's ability to supply all your needs—large and small—for both hazardous and non-hazardous installations.

Write for the Killark catalogs.

Killark

ELECTRIC MANUFACTURING COMPANY
Vandeventer and Easton Ave. • St. Louis 13, Missouri
In Canada: Killark Electric of Canada, Ltd., 421 Islington Ave. South, Toronto 18, Ont.

6101



1 **UNI-BUS DUCT**
Plug-in convenience . . . any

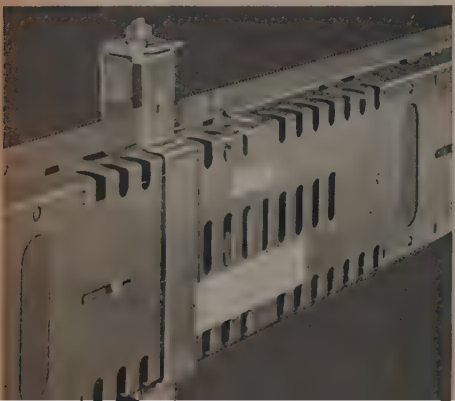
2 **UNI-BUS PLUG-IN DEVIC**
Use anywhere; completely

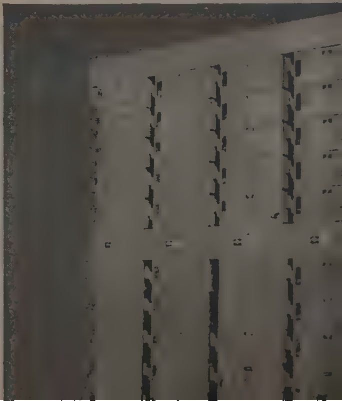
3 **UNI-BUS PLUG-IN CENTE**
Replace panelboards with p
convenience and safety!

1. HALF THE WEIGHT of most other ducts; selective low voltage drop; easier installation; easier maintenance . . . yet Uni-Bus costs no more! Family of six types for all industrial, commercial, laboratory and high rise building needs. Rated 100-4000 amps., 600 volts.

2. COMPLETE SAFETY, COMPLETE CONVENIENCE with Uni-Bus Plug-in devices which provide branch circuits at every 10 inches of Uni-Bus duct . . . or in stacks in the new Uni-Bus plug-in distribution centers. Patented interlocks make it impossible to touch a live part!

3. PLUG-IN POWER for distribu
motor control, and lighting panels is
vided by new, flexible Uni-Bus Plu
centers. Plug-in Trof design takes
less space; provides groupings of 2 t
locked plug-in outlets in 20 inch
enclosures.





CONTROL

A new approach to in-plant power

Uni-Bus makes your entire distribution system a plug-in switchboard!

Get low voltage drop, easy installation, the ultimate in flexibility, safety and power availability...yet you pay no more!

Here's an entirely new kind of distribution system that provides all you need in accessible and flexible circuit protection right from the main disconnect to the ultimate use!

It's so safe you can't touch a live part anywhere in the system . . . so convenient you can plug in any place, any time . . . so lightweight and easy to assemble you can cut installation and maintenance time drastically.

That's not all! Better design gives better electrical performance . . . low voltage drop; no derating regardless of mounting plane.

Uni-Bus is so flexible you can revise it readily even if your plant layout changes every year. No obsolescence . . . duct, plug-ins and fittings are 100% reuseable.

Look at this list of Uni-Bus features. Don't you see a *better* answer to *your* power distribution problems?

Standard Components—Uni-Bus is a complete system featuring interchangeable parts all the way. Uni-Bus requires less than ¼ of the accessories of ordinary busway.

No Specials—Off-the-shelf lengths mean you can tailor straight runs within 2½". Exclusive flexible connectors take care of special turns and offsets.

Low Impedance—Ratings are increased through use of multiple bars scientifically spaced . . . specially insulated aluminum and copper bus bars are supported and air spaced by durable polyester glass insulators in ventilated steel enclosures.

Easy to work on—Complete safety not only protects life but also means worry-free, quicker work with less downtime for maintenance or alterations.

A system that grows—Plug-in centers grow with your needs. Plug in another standard device . . . or add another standard plug-in trof. No need to wait while somebody assembles and wires a new panelboard.

Next time you build, remodel, or expand a plant get the busway system that gives you so much more. Choose Uni-Bus . . . the complete power distribution system with complete plug-in safety, convenience, and economy.

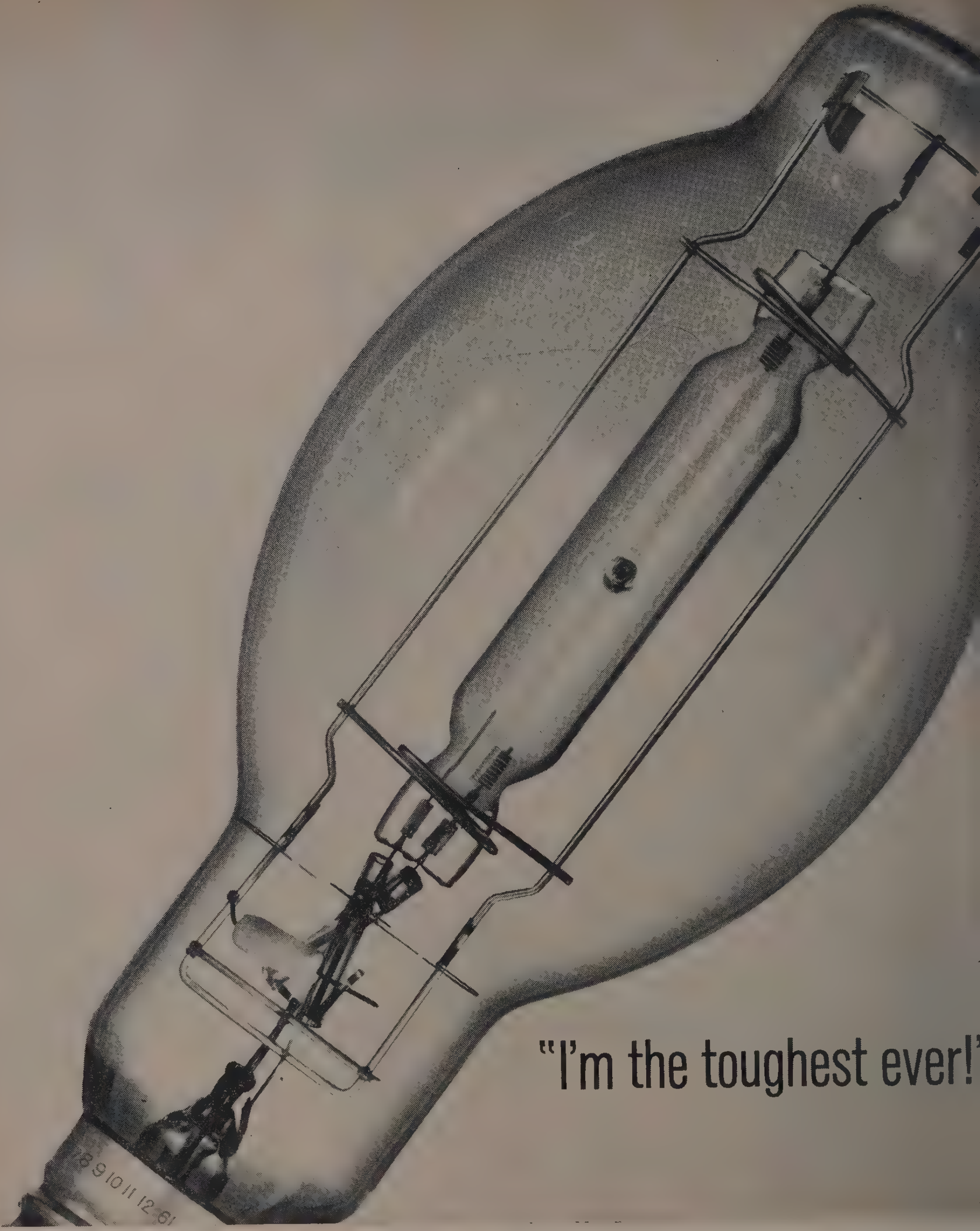
See your Cutler-Hammer distributor or representative today! Or write direct for Publ. LU-23-J241 on Uni-Bus duct systems and plug-in distribution centers.

WHAT'S NEW? ASK...

CUTLER-HAMMER

CONTROL

Cutler-Hammer, Inc., Milwaukee, Wisconsin • Divisions: AIL; Mullenbach • Subsidiaries: Uni-Bus, Inc., Cutler-Hammer International, C.A. • Associates: Cutler-Hammer, Canada, Ltd.; Cutler-Hammer, Mexicana, S.A.



WORLD'S TOUGHEST MERCURY LAMP G

New one-piece unbreakable steel frame makes Sylvania Rough Service Mercury Lamp the toughest, longest-lasting, most vibration-proof mercury lamp ever built. Meet the new and undisputed champion!

Look at that build! Until now mercury lamp frames were made of many metal pieces welded together. They burned with the ever-present danger of a weld breaking. Many premature failures are due to this one cause.

But now Sylvania brings you a frame that is one solid structured piece of nickel-plated steel—ounce for ounce as tough as a steel girder. Cannot bend. Cannot break. You ge full 12,000 hours of useful life you pay for. And whe arc tube was once suspended inside with many welded p this ingenious new frame actually *clamps* it in place. *F* on all four sides. *Exactly* in position to give the most from reflectors. Not even a missile blast can jar this arc loose or knock out the light from this lamp.

The heat shield, too, is part of this one-piece frame. the double leaf spring supports are even reinforced to doubly sure the frame stays exactly in place. With al you still get unsurpassed Sylvania lumen output. Plus

EW UNBREAKABLE BACKBONE!

d hard glass shell. Plus Sylvania's convenient lifetime ing base. Plus Sylvania's exclusive Certified Perform- Policy.* Sylvania Rough Service Mercury Lamps are y available in the 400-watt size. More on the way. ll at regular prices!

ur Sylvania representative—or write us way! Lighting Division, Sylvania Elec- roducts Inc., Dept. 15, 60 Boston Salem, Mass. In Canada: Sylvania (Canada) Ltd., Montreal.

***CERTIFIED PERFORMANCE POLICY GUARANTEES:** "Sylvania Mercury Lamps may be returned to the supplier for full exchange if they fail in less than 1000 burning hours, and thereafter (up to 5000 hours) for pro-rata exchange, in accordance with a pro-rata exchange value table set forth clearly in the policy form."

SYLVANIA

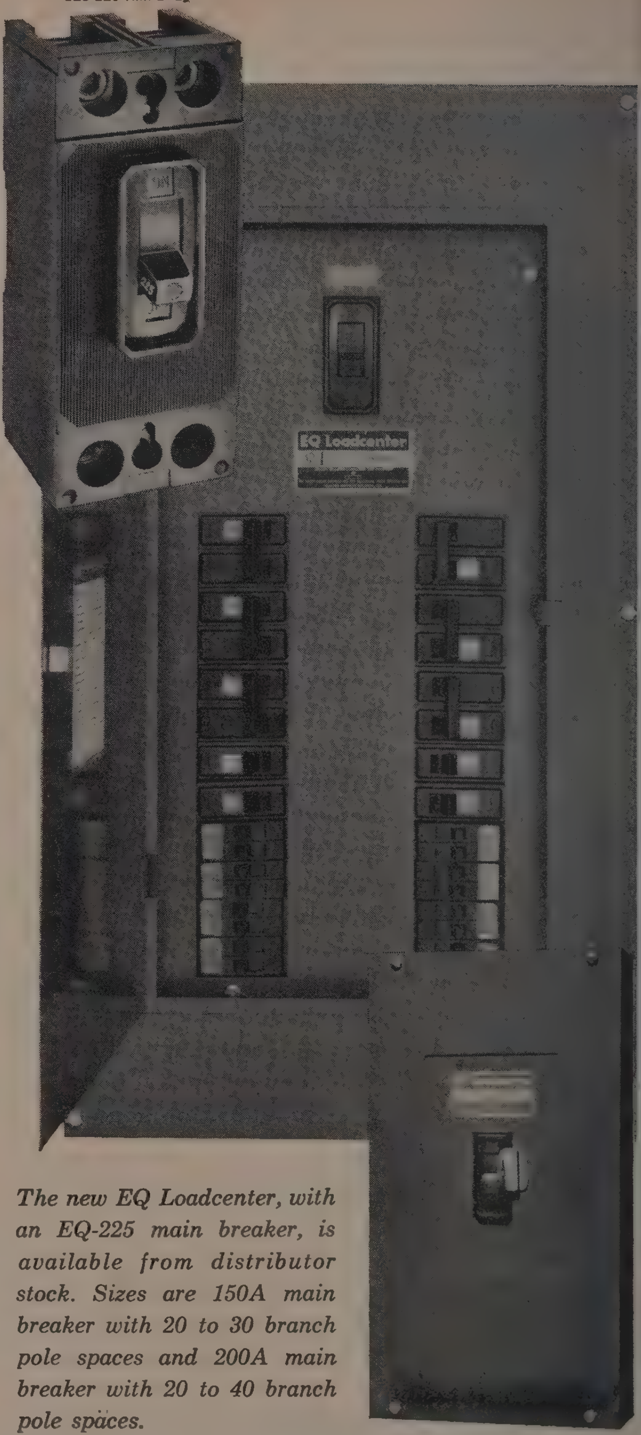
GENERAL TELEPHONE & ELECTRONICS

NEW
EQ®-225 AMP. BREAKER

SAME
FAMOUS I-T-E QUALITY

Now available under the I-T-E label are the new EQ-225 circuit breaker, new EQ-Loadcenter with 150A or 200A main breaker, and enclosed EQ-225 breakers . . (NEMA Type 1, 1B and 3) . . in ratings of 125, 150, 200 or 225 amperes. These new modern, compact devices provide positive protection against overload or short circuit conditions. The EQ-225 employs Quick-make, Quick-break, Trip-free mechanism action with common trip (not companion trip). A fault to ground automatically opens both poles of the breaker! Overcurrent protection combines the time proven thermal magnetic principle for positive protection against overload or fault conditions. For additional information, contact your nearest I-T-E District Office, or your local I-T-E Authorized Distributor.

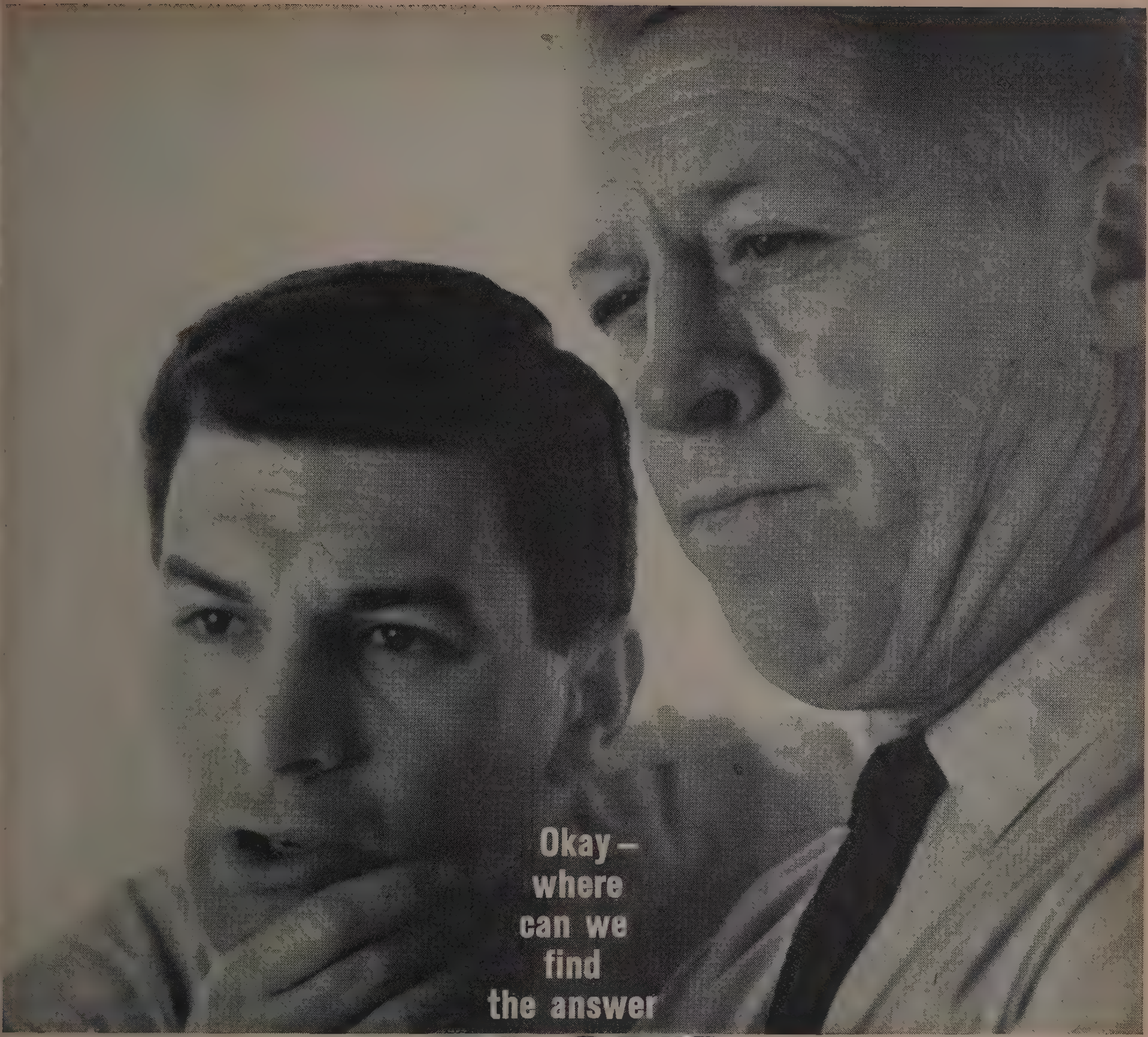
New EQ-225 AMP BREAKER
2 POLE 120/240 VOLTS A-C
125-225 AMPERES



The new EQ Loadcenter, with an EQ-225 main breaker, is available from distributor stock. Sizes are 150A main breaker with 20 to 30 branch pole spaces and 200A main breaker with 20 to 40 branch pole spaces.

for the Contractor who is Proud of his work

I-T-E CIRCUIT BREAKER COMPANY



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If you find it increasingly difficult to get the up-to-date, expert information you need when you need it—here is important news from McGraw-Hill. A new professional encyclopedia has been developed that gives you latest available information in the scientific and engineering disciplines, and keeps you abreast of the whole spectrum of today's exploding technology.

Short-Cut to Basic Information on Every Aspect of Every Field: For help with everyday problems met in your work—as an instrument to help you bridge the gap between your specialty and other fields into which your work leads you—as a backstop and "refresher" in your own and related areas—there is no substitute for this new ready-reference tool in encyclopedia form. McGraw-Hill enlisted the support of 2,000 contributors, including Nobel Prize winners and leaders of research and industry, for this unprecedented and widely-acclaimed undertaking.

Mail Card for Free Brochure: If you feel pressured by the mountain of information facing the scientist and engineer today, the helpful brochure offered on the attached card is "must" reading for you. It gives complete details of this extraordinary new method devised to answer your information needs. Simply mail the inquiry card today to receive your free copy. No obligation, of course.

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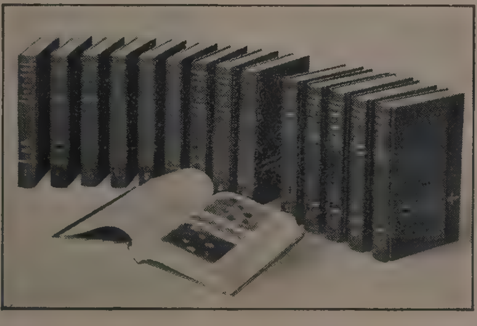
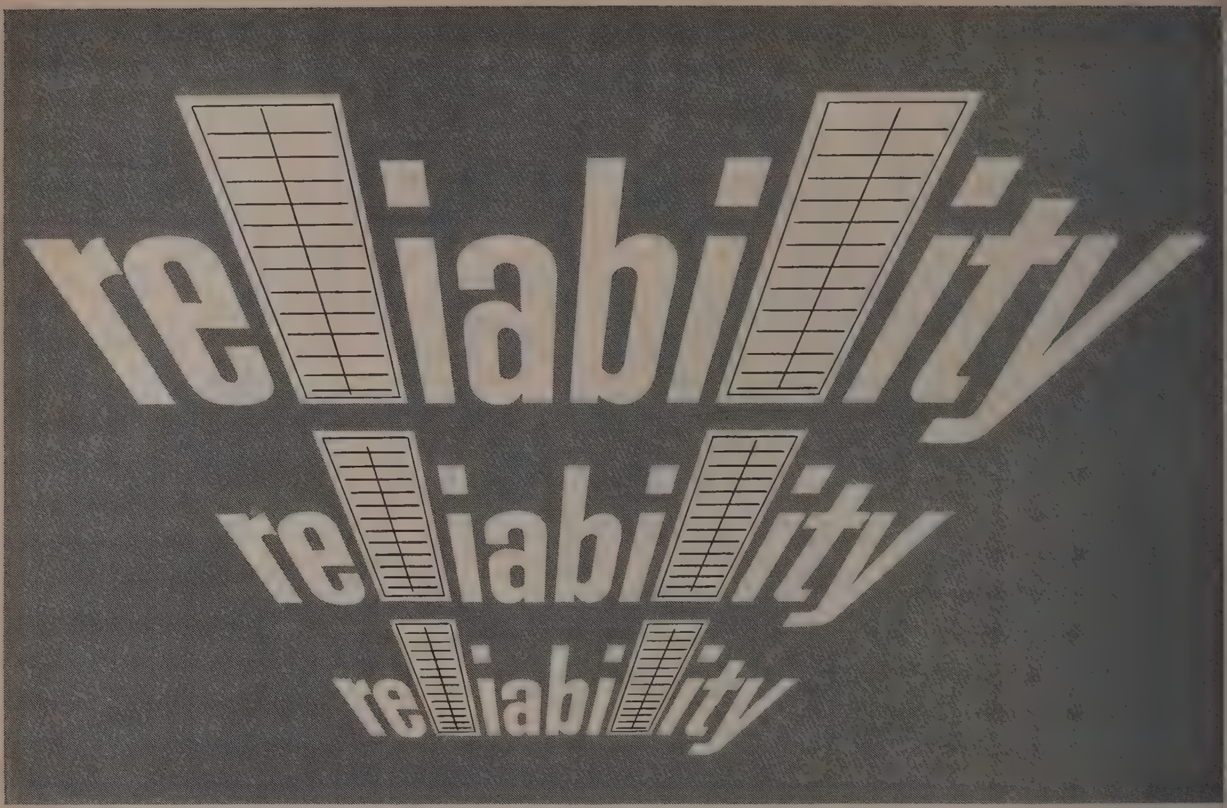




SOLA CONSTANT-WATTAGE FLUORESCENT BALLASTS

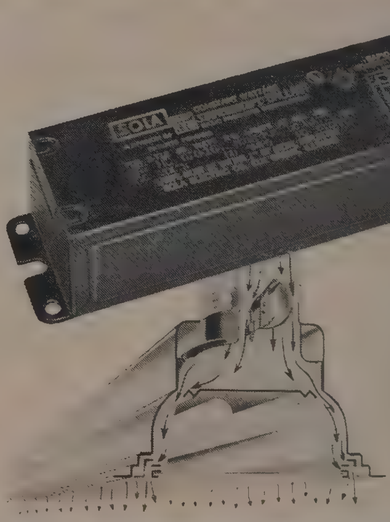
Specified for the Harris Trust and Savings Bank (Chicago) — these remarkably reliable SOLA two-lamp fluorescent ballasts! Here, in this specially tailored installation, heating and cooling are handled via the lighting troffers, an arrangement designed to assure Harris Trust and Savings Bank complete flexibility in placement of partition walls, with ample light and ventilation for all areas.

25,000 SOLA 40-watt ballasts are employed throughout the building. Records, after two years, show the kind of cost-saving reliability that built our business here at SOLA; 99.9% of these ballasts still are trouble-free, faithfully doing their job without attention.

Actually, it's not surprising. Records of SOLA ballasts prove that 99.86% surpass warranteed performance! And SOLA constant-wattage design insures better striking with open-circuit RMS voltage well above minimum requirements . . . plus full rated lamp life through low lamp current crest factor.

It pays to specify SOLA every time. Write today for complete catalogs and prices.

S-32-61



SOLA 40-w Rapid-Start ballast — the type employed in Benjamin Lumi-flo light-and-air troffers (left) throughout the new Harris Bank Bldg. shown below.

SOLA

DIVISION OF BASIC
PRODUCTS CORPORATION

B P
C

SOLA ELECTRIC CO.
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Elk Grove Village, Ill.
HEmpstead 9-2800
IN CANADA, Sola-Basic
Products Ltd., 377 Evans
Ave., Toronto 18, Ontario

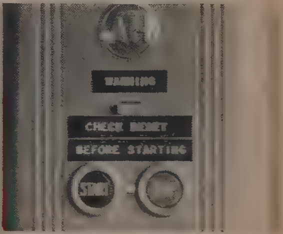
PERSONALIZING

HARD HATS

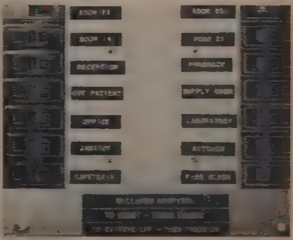
FUSE BOXES

RAISED LETTER LABELS MADE ON THE SPOT

If it can be mistaken, mislaid, misfiled, misused, misanything—label it with Dymo. See for yourself how easily you can make handsome, raised-letter labels for 1001 applications. Embossed labels take seconds to make, cost pennies, stick permanently to almost any surface. Vinyl tape in 10 colors, five striped tapes, six metal tapes. Five Dymo Tapewriter models, from $24.95. Send the coupon for a free booklet "1001 Applications" for manufacturing, administrative, inventory, personalizing, professional, electrical, municipal, schools, electronics, and many more – along with a name badge personalized with your name.



CONTROL BOXES

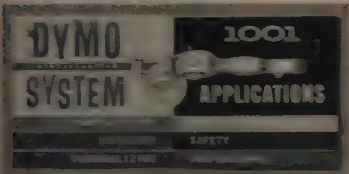


CIRCUIT BREAKERS

Embossed letters provide maximum permanent legibility, quality appearance.

DYMO
INDUSTRIES, INC.

Prices slightly higher in Canada

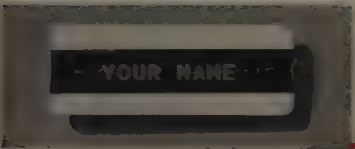


WRITE FOR FREE BOOKLET "1001 APPLICATIONS" AND YOUR SAMPLE NAME BADGE

Dymo Industries, Inc., Department ECM-5
P.O. Box 1030, Berkeley 1, California

Please send me free booklet "1001 Applications" and my name badge as follows.

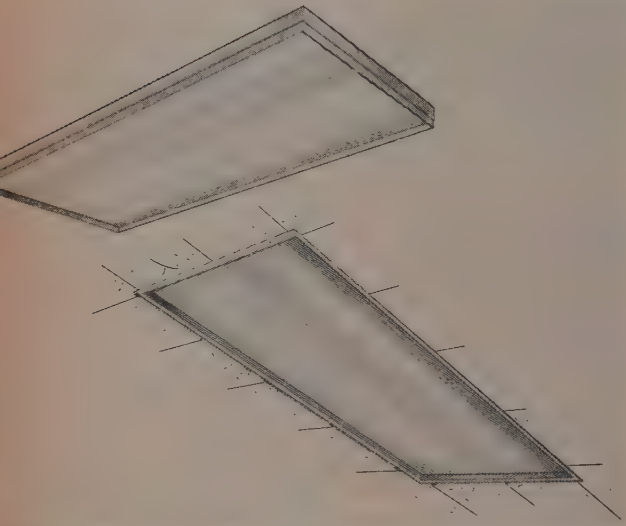
Name ______________________________ (PLEASE PRINT)
Title: ______________ Firm ______________
Product or Service ______________ Tel. ______________
Address ______________________________
City ______________ Zone ______________ State ______________



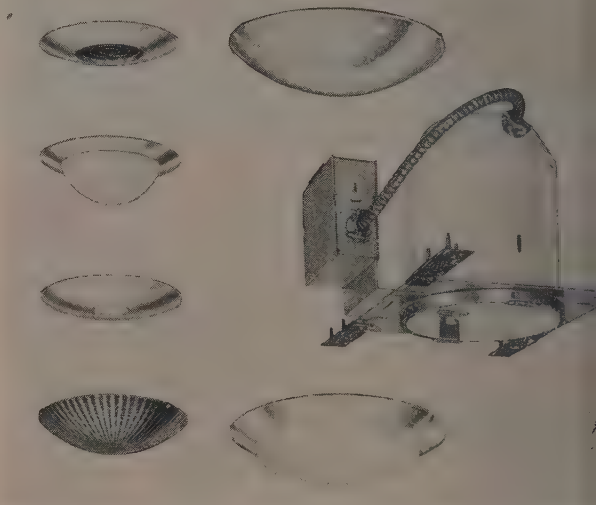
GOOD LIGHTING PAYS EVERYON
...BE SURE TO GET YOUR SHARE

Graybar's Lighting Action Plan helps you get it! Graybar gives you the tools for selling . . . quality lighting equipment, priced to fit every budget...available from your local Graybar stocks. Also, you're able to offer financial help through Leased Lighting—at no risk or cost. And . . . you have all of Graybar's know-how for help in planning, layout and specification. It's all in the Graybar Sales Kit which

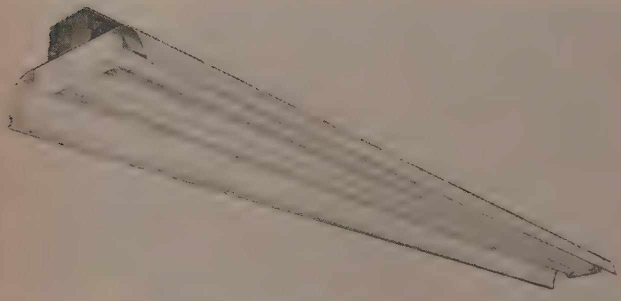
includes such helpful items as a con
plete Lighting Prospect Plan Book,
Light Meter, Lighting Selector and oth
sales aids. But time is money—you
money, so act now on the Action Pla
Ask your local Graybar man, or wri
Action Plan, Graybar Electric Compan
Inc., 420 Lexington Avenue, N. Y. 17, N.
and...call Graybar for
everything electrical. Grayba



BENJAMIN: Outstanding style and economy in Benjamin's Modular-Troffer for recessed or surface mounting; Prismatic Lens or ½" Cube Plastic Louver. Fixture is one-piece steel housing; baked enamel finish. Suggested user price $29.60 with two 40 W Rapid Start Lamps, $47.65 with four lamps. Troffers at slight additional cost in flange construction with integral swing-out hangers.



MOE LIGHT: Prewired Adjust-All round recessed housing with choice
40 decorator combinations of Open Trim, Trim-and-Glass and Decorati
Glass including satin brass or aluminum, chromium, baked enamel, p
ished brass, Fresnel lenses, opal glass, white glass, etched glass.

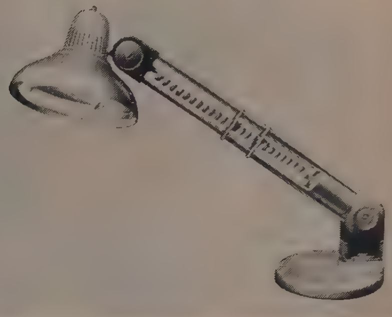


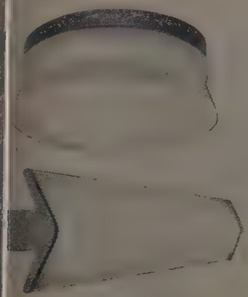
KEYSTONE RLM FEATURE-LITE INDUSTRIAL: Here's top efficiency lighting with 12% upward component, lifetime porcelain enameled reflectors and high power factor fused ballasts. In 4-foot, 2-lamp Rapid Start suggested user price $21.65; 8-foot, 2-lamp Slimline suggested user price $36.65.

GE POST MOUNTED FLUORESCENT: Sturdy aluminum hous
with acrylic plastic light diffusing globe and aluminum reflec
Internally prewired for quick, easy installation; optional ph
electric control available. Suggested user price $130.00;
control, $138.00.

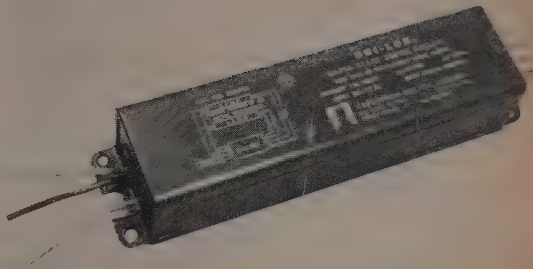
WAKEFIELD PRISMATIC: Popular, practical, inexpensive Wakefield Prismatic luminair has ⅛″ thick clear lens diffuser of styrene, easily removed without tools. Prismatic 50 has two Rapid Start lamps for 50 footcandles—suggested user price of $20.75; Prismatic 100 uses four lamps for 100 footcandles at $34.75.

AMPLEX: Advanced lighting uniquely combining fluorescent and incandescent. Instantly adjustable lamp, high quality light for office, plant or laboratory...in clamp-on, screw-down or draftsman-clamp mounts. Suggested user prices from $27.40.





LITECRAFT VALULITE: Fixtures that feature beauty in opal glass and anodized aluminum; hinged ceiling drums for easy relamping. With two 75 W lamps, suggested user price $6.40, three 100 W lamps, $10.00. ■ Litecraft also features fluorescent fixture with reversible plastic diffuser for horizontal or vertical mounting on wall or ceiling. Suggested user price with 40 W Rapid Start, $13.35.



JEFFERSON DRI-LOK: Ends danger of compound leakage. Dri-Lok is a new thermo-setting plastic, bonding ballast core, coil and case into one unit. Will not react or combine chemically with any material in ballast. Ballast operates cooler for longer operating life.

MOLDCAST HOUR GLASS: Modern design in cast aluminum fixtures for sealed beam lamps. The Hour Glass is the only cast aluminum, weatherproof fixture of its kind, complete with protective lens and canopy plate. Satin aluminum finish protected by clear plastic coating. Suggested user price $25.17.

NTHONY "THRIFTY-Q": Cool, con-
rolled Quartz-Iodine lighting. Cast alu-
minum fixture for rapid heat dissipation;
igh-temperature Neoprene gaskets. In
wo models; 500W/120V, suggested
ser price $30.65 and 1500W/277V
t $38.65.

WIDELITE: For 100, 175, 250, 400 and 1000 W color-corrected mercury vapor lamps, quartz-iodine lamps or incandescent lamps, or in combination. Die-cast aluminum bodies resist corrosion and damage; heat dissipating fins promote longer operating life. May be mounted on walls, poles or hung; in single or multiple units. Choice of reflectors for different beam coverage. Available in all voltages at suggested user prices from $42.00.

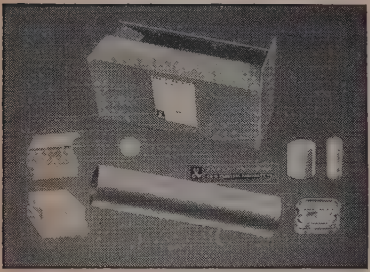
STERNER LIGHTING: Low
est installed cost per lume
output of any outdoor fluo
rescent. Davit lights ar
complete down to mountin
bolts, internally wired wit
HPF ballast in base for eas
servicing through patente
"Hinge-O-Matic", allowin
one-man relamping and low
cost initial installation. Pol
and lamp are fastened t
base with heavy-duty hing
for quick manipulation. I
natural aluminum or ano
dized finish. Suggested use
prices range from $377.0
to $472.00, including pole
and all equipment. Als
available in double-davi
construction. ■ Circa-Lit
also features exclusiv
"Hinge-O-Matic" for ease o
installation and mainte
nance. Suggested user price
from $268.00 to $535.00
including poles.

Here is part of the wide selection of fixtures we carry...
in stock at Graybar...headquarters for lighting and lamp

STAYS SPLICED!

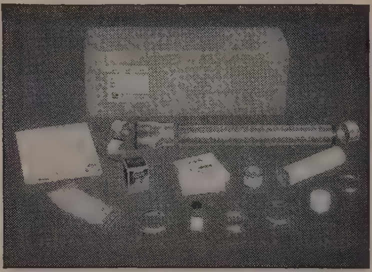
G&W furnishes everything needed in one package for complete, durable, trouble-free cable splicing . . . you save time, money, and material!

G&W pre-engineers a full line of splice kits for both lead and plastic-sheathed cables. Each kit is supplied *complete* with all required materials, drawings, and instructions. Containers are *sealed* so nothing is lost. You save-on-the-job installation time; reduce inventory costs. Fast delivery to you, too, from factory off-the-shelf stock!



PAPER-LEAD CABLE SPLICING KITS

. . . available from stock for all standard size (number of pairs) cables over the full range from #12 AWG through #19 AWG. May be supplied for straight two-way, bifurcating or bridge, and four-way "X" splice configurations. Both paraffin and desiccant type kits are also available. G&W can furnish kits designed to meet special applications.



PLASTIC-COVERED CABLE SPLICING KITS

. . . available from stock for straight two-way, three-way wye, or four-way wye splice configurations. Contain easy-to-use 2" I.D. (maximum) plastic pipe sleeve threaded at each end to take single or wye-type end caps and seals. Sleeve offers excellent insulation; resists sunlight, dampness, alkalies, acids, and oils. Other kits also available for both copper or aluminum shielding.

G&W CABLE NIGHTCAPS

. . . seal unfinished cable joints against moisture and dirt; eliminate need for splicing as one continuous operation. Nightcaps permit terminations to be left partially completed overnight or for several days with assurance that work-in-process will stay dry and clean. All needed materials supplied in single package, are low in cost, and quick-and-easy to use.

You can depend on G&W's *full line* of quality splice kits, nightcaps, or cable boxes to give you the service and protection your system deserves. For full information, contact your nearest G&W Representative, or write for any of the following G&W Bulletins:

Bulletin JC56 ......**Lead-covered cable splice kits**
Catalog JD ....**Plastic-covered cable splice kits**
Bulletin XYZ ....**Cable joint nightcaps**

G&W

G & W ELECTRIC SPECIALTY COMPANY
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CANADIAN MFR. • POWERLITE DEVICES LTD. • TORONTO, MONTREAL & VANCOUVER

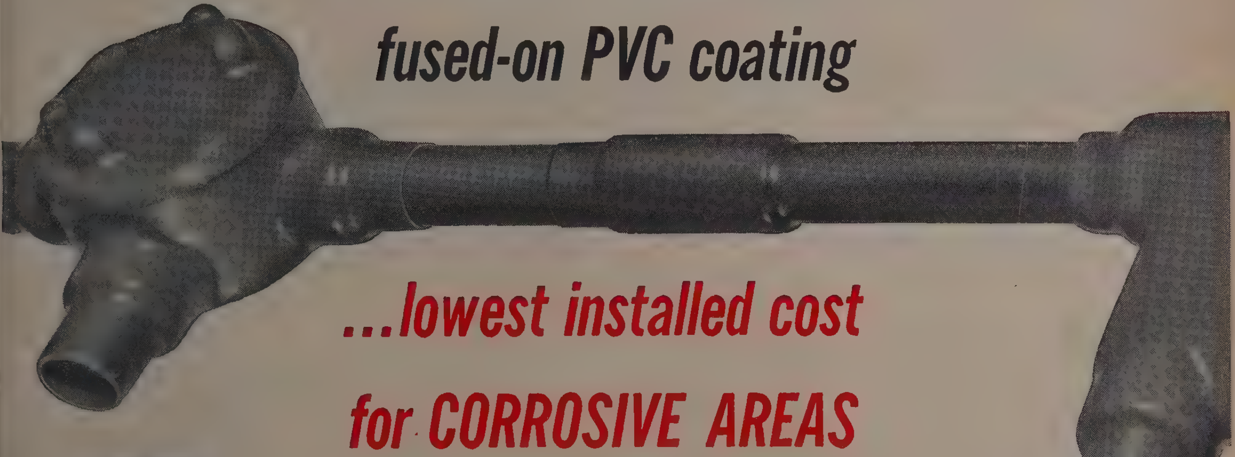
J62-2

superior quality standards — inspired specialized design

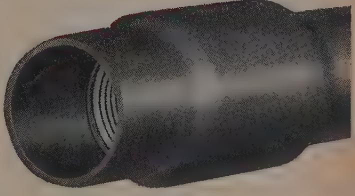
Investigate

PLASTI-BOND*

the only complete conduit system permanently protected by fused-on PVC coating



...lowest installed cost for CORROSIVE AREAS



Plasti-Bond is Pittsburgh Standard hot dip galvanized steel conduit, elbows, and couplings, heavily coated with polyvinyl chloride *permanently fused-on at the factory*. Overlapping sleeve design creates tight, pressure sealed joints on couplings and condulets, provides complete protection against corrosive fumes. There is no "corrosion travel", no fume seepage.

Plasti-Bond's unique protection costs less installed than any other effective corrosion-resistant electrical system. *Standard conduit installation methods and tools are used with little or no alteration in technique.*

Complete corrosion-proof conduit systems can be specified in Plasti-Bond, including *Crouse-Hinds* condulets, lighting fixtures, straps, and pull boxes to meet all requirements.

Get the full story on the finest PVC-protected electrical system. Write today.

*Patent Pending

Write for samples and literature.
Pittsburgh Standard Conduit Company,
Verona, Pa.

PLASTI-BOND

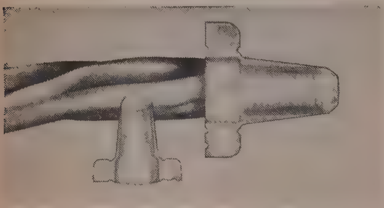
PITTSBURGH STANDARD CONDUIT CO.

GENERAL OFFICE: VERONA, PA.

Plants: Verona, Pa. • Morrisville, Pa. • Houston, Tex. • Franklin, Pa. • Gilmer, Tex.

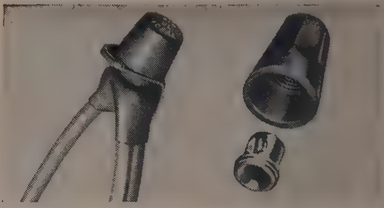
Maintenance Mart

THESE POPULAR IDEAL PRODUCTS ARE ALL AVAILABLE FROM YOUR LOCAL DISTRIBUTOR



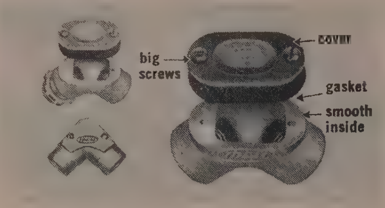
Built-in wrench. Unique wings make WING-NUT easiest wire connector to screw on heaviest branch circuit wires. Splice is visible inside tough nylon shell. U.L. listed for 600 volts as pressure cable connector, and 105°C. U.L. approved for aluminum and solid and/or stranded copper wires. 2 sizes of WING-NUT available to meet all pigtail splice needs.

America's favorite! WIRE-NUT has long-proven performance record as lowest-cost method for all common branch circuit and fixture wire connections. Strongest, shake-proof wire joint possible. All 5 sizes U.L. listed as 300v fixture; large sizes 74B & 76B as 600v pressure cable connectors. Use WIRE-NUTS in all types of conduit, cable, non-metallic sheath and open wiring.



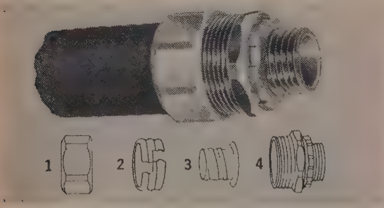
Select Set-Screw or Crimp. Only Ideal CRIMP has WRAP-CAP that insulates all around and even between wires. 600v U.L. approved for cadmium plated steel sleeve and vinyl 1-piece WRAP-CAP . . . now 2 sizes. 3 sizes of Ideal SET-SCREWS. All U.L. listed. Shell and connector easily removed and re-used. Tough shell has long skirt to prevent flash-over.

Cut "fishing" time. Highest grade, oil-tempered flat spring steel FISH TAPES will not curl. Flexible and easy for long, multi-bend conduit runs. Steel reel holds tape, is handled with safe, sure grip and ends danger of bending, kinking or breaking tape. Used with flexible leader, solves 90% of fishing problems. 1/8" and 1/4" tapes in 50, 100 and 200 foot coils.

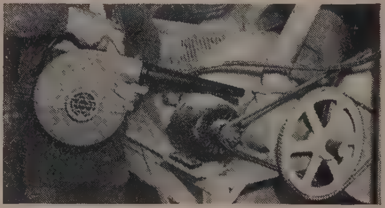


Easiest way around! Ideal PULLING ELBOWS & ADAPTERS make wiring around corners a snap. Precision milled of malleable iron for rugged strength and perfectly smooth pulling. Precise 90° fit. Cadmium plated, chromate treated. Supplied assembled, complete with rigid domed cover, full neoprene gaskets and BIG screws. 1/2" to 2" sizes, in three styles.

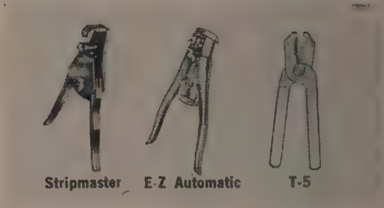
Double protection—Ideal VOLTAGE TESTER has a solenoid, calibrated indicator and a neon test lamp . . . each independent of the other. Safest, easiest for rugged daily use. Plastic safety yellow case, no-slip prods, prod storage space, fits pocket. Tests voltage, frequency, AC or DC, continuity, etc. Also model with resistor-fuses in prods to prevent arcing.



Vap-Oil-Tite—only completely reusable connectors for liquid-tight, flexible metallic conduit. Perfect seal. Positive ground, covers raw conduit end, fits EF and UA. U.L. approved. 90°, 45° and straight for 3/8" to 4" sizes. Easy to apply: Slip ring nut (1), and split ring (2), on conduit. Screw grounding bushing (3) inside conduit. Tighten ring nut over connector (4).



Vacuum cleaners and blowers. Blows dry air at high velocity but low pressure, so safe for delicate equipment. Light, balanced hand models for heavy, medium or light duty, complete with blower nozzle. Available with hand model or tank type cleaning attachments. Ideal CLEANERS do better job faster, at less cost. Universal type motor lubricated for life.



Strip wires fast and easy. "One-squeeze" STRIPMASTER strips both solid and stranded wire in 2 seconds. Heavy-duty E-Z AUTOMATIC cuts thru toughest insulation and strips wires clean without crushing ends. Low cost T-5 STRIPPER cuts, strips and loops wires. Fits flat in pocket. Strips 10 to 18 gauge. Many other special Ideal hand stripper models available.

In-place motor maintenance. Service commutators, motors without dismantling . . . use Ideal commutator resurfacers, brush seaters, flexible abrasives. All sizes and styles to fit any job. Ideal line also includes everything for commutator care: precision grinders, mica undercutters and many specialized small tools. See your distributor.

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starter
units with no wiring to disconnect. No shutdown of ther units. Simplifies inspection, speeds fuse and contact-tip replacement. One of ore than 40 time- and money-saving features of the ***7700-LINE CONTROL CENTER.*** hey add up to best protection, fastest installation, easiest maintenance in your new rouped control. See your G-E Sales Representative or write for Bulletin GEA-7238 to ect. 783-24, Schenectady, N.Y. *General Electric Co., Salem, Va. and Plainville, Conn.*

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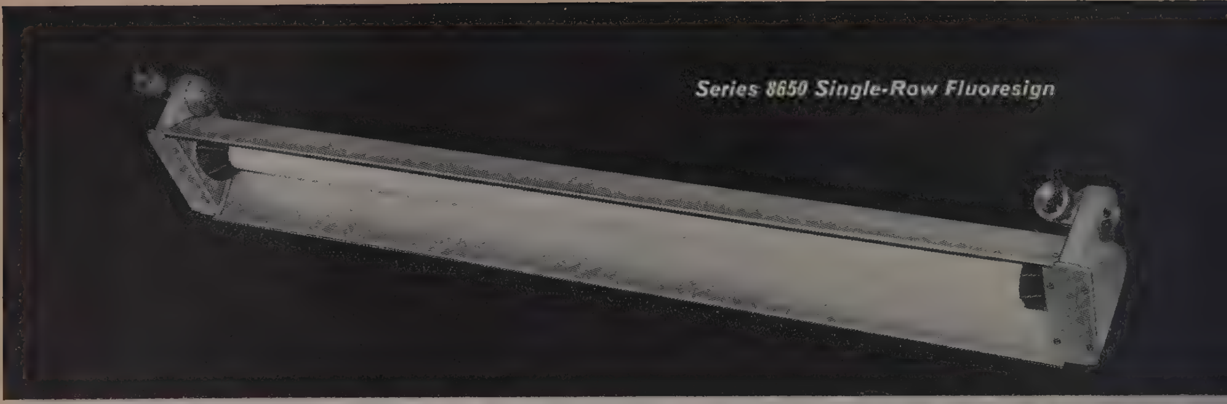
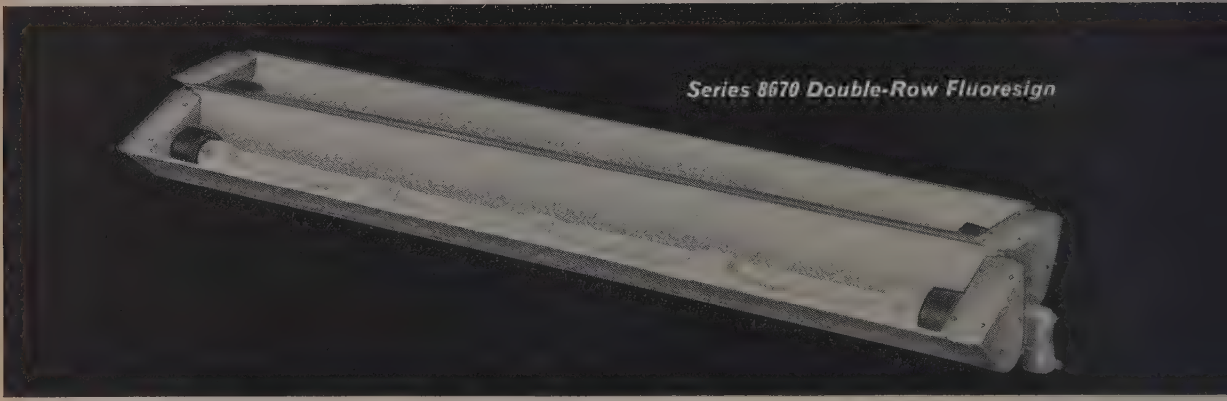

Series 8650 Single-Row Fluoresign


Series 8670 Double-Row Fluoresign

Versatile Revere Fluoresign lets you make attractive, efficient lighting systems for a wide range of applications

The Revere Fluoresign consists of standard, modula components including socket assemblies and 4, 6, an 8-foot reflectors and covers. It lets you make up a economical, attractive fluorescent lighting system of an length and any desired intensity for illuminating stor fronts, building walls, signs and poster panels.

You can choose the degree of lighting intensity required for the application. The Fluoresign accommodates all high-output and extra-high-output lamps. It i available in either single-row styles (Series 8650) o double-row styles (Series 8670). You can install th Fluoresign with light directed upward using the snap-o reflector cover, or you can install it with the light directe downward using the slide-in reflector cover.

The Fluoresign is easily assembled and installed an is adjustable for accurate placement of light while th lamps are burning. Because it runs the entire length o the area to be lighted, with no gaps between reflector the light is uniform with no glare or hot spots. All-compressible sockets and easy-to-remove covers permit eas relamping and maintenance. Write for Bulletin 300-21

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Save time on the job with a SEALTITE® cutting jig

quick, clean cuts for dependably liquid-tight seals

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FOR MORE INFORMATION on SEALTITE Cutting Jig or on SEALTITE, write: Anaconda Metal Hose Division, Anaconda American Brass Company, P.O. Box 791, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., Montreal 2, Quebec.

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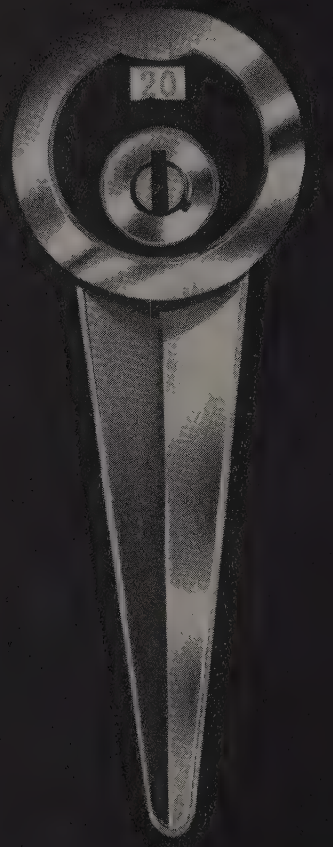
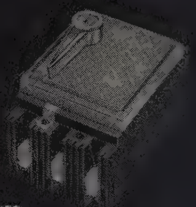
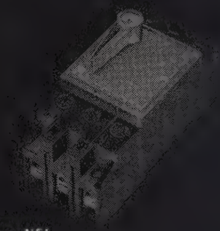




Type NEF



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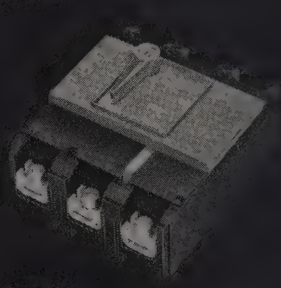

Type NJL

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the rotary handle...

A totally new concept in circuit breaker design and operation, the rotary handle on FPE molded-case circuit breakers offers you advantages never before available in AB breakers:

Simplest and safest in the industry! All external mechanisms are eliminated. The rotary handle is built into the breaker, assures you greater safety and dependability, greater visibility!

Eliminates all safety hazards! The breaker may be locked "on" or "off" with the door open or closed! And a retractable locking ring (standard on every unit) accommodates up to 3 padlocks!

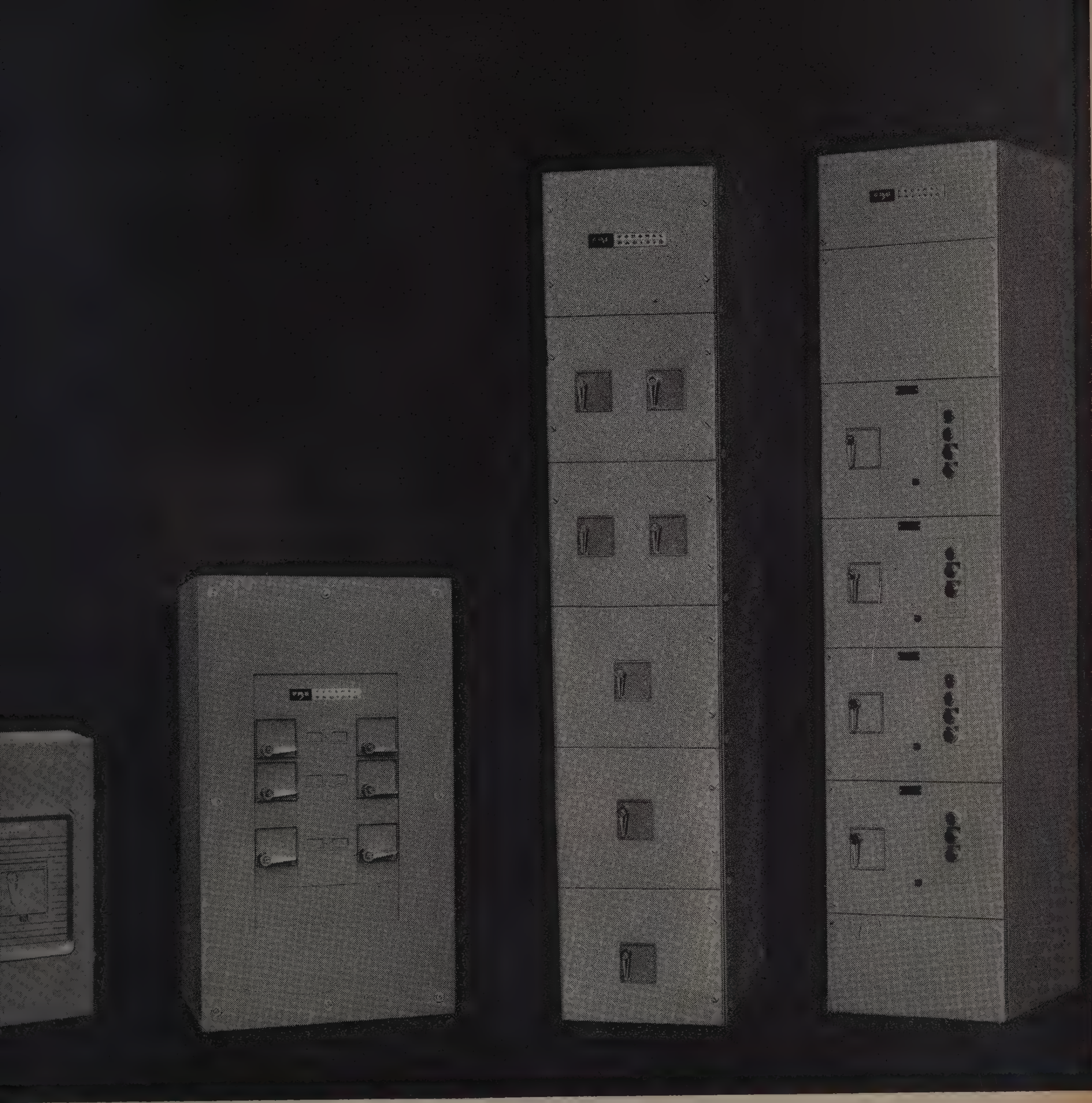
Easiest to operate! The rotary handle, with lever action, operates much more easily—obsoletes straight-line toggle devices!

Styling, too! Raymond Loewy-designed! When it comes to style and appearance, FPE rotary handle circuit breakers speak for themselves!

in only 4 frame sizes...

Here's real economy in AB breakers! Now, with FPE rotary handle breakers you get full-line capability—15 through 800 amps, 2 and 3 p in only 4 frame sizes! Savings to you are obvious, in specifying, or ... stocking ... handling! Check these ratings:

Continuous Current, amps	Type	Max. Voltage, ac	Interrupting Capacity, amps @ 600 vac.	@ 480 vac.	@ 240 vac.	Trip
15-100	NEF	480	—	15,000	20,000	thermal and magnetic
70-225	NFJ	600	15,000	20,000	25,000	thermal and adjustabl magnetic
70-400	NJL	600	20,000	25,000	40,000	thermal and adjustab magnetic
125-800	NM	600	25,000	35,000	50,000	thermal and adjustab magnetic interchange



ves you safety, simplicity...savings in power control equipment!

orld's most advanced power control equipment is identified by the
s most advanced molded-case circuit breaker. Modular construction
hout plus pre-drilled and tapped components assure maximum flexi-
o meet tomorrow's protection needs.

ually enclosed rotary handle circuit breakers rated through 800
es obsolete external handle mechanisms, provide simplified low-cost
ations. The door interlock prevents unauthorized opening of enclosures
reaker in "on" position. The interlock is voidable by authorized person-
ew reduced size of the circuit breakers results in smaller enclosures.

oution Panelboards—types NHDP and CDP—are available with rotary
e circuit breakers in a full range of sizes from 15 to 800 amps. Each
er can be individually locked either "on" or "off". A glance at the highly
e rotary handle tells you whether the breaker is "on", "off" or "tripped"
eel front panel construction and individual grounding of each cover
assure maximum operator safety.

bboards—600-volt AC—types HCB and VCB—are engineered for use in small and medium-to-large buildings, respectively. HCB main distributor sections are rated through 2000 amps, VCB through 6000 amps. Branch circuits, with rotary handle circuit breakers, are rated through 800 amps.

Control centers feature modular motor starter units in NEMA sizes 0 through 5, and rotary handle circuit breakers. Busses are enclosed in polyester glass ...75,000 amperes RMS short circuit withstand is standard. Standard control center sections are 20" wide x 20" deep x 90" high. Units plug in through the insulator, assuring dead front safety. Exclusive plug-in construction allows door to be closed and locked with the unit completely disconnected from the power source. Single responsibility for the manufacture of structure and components assures properly coordinated assemblies engineered to exacting standards.

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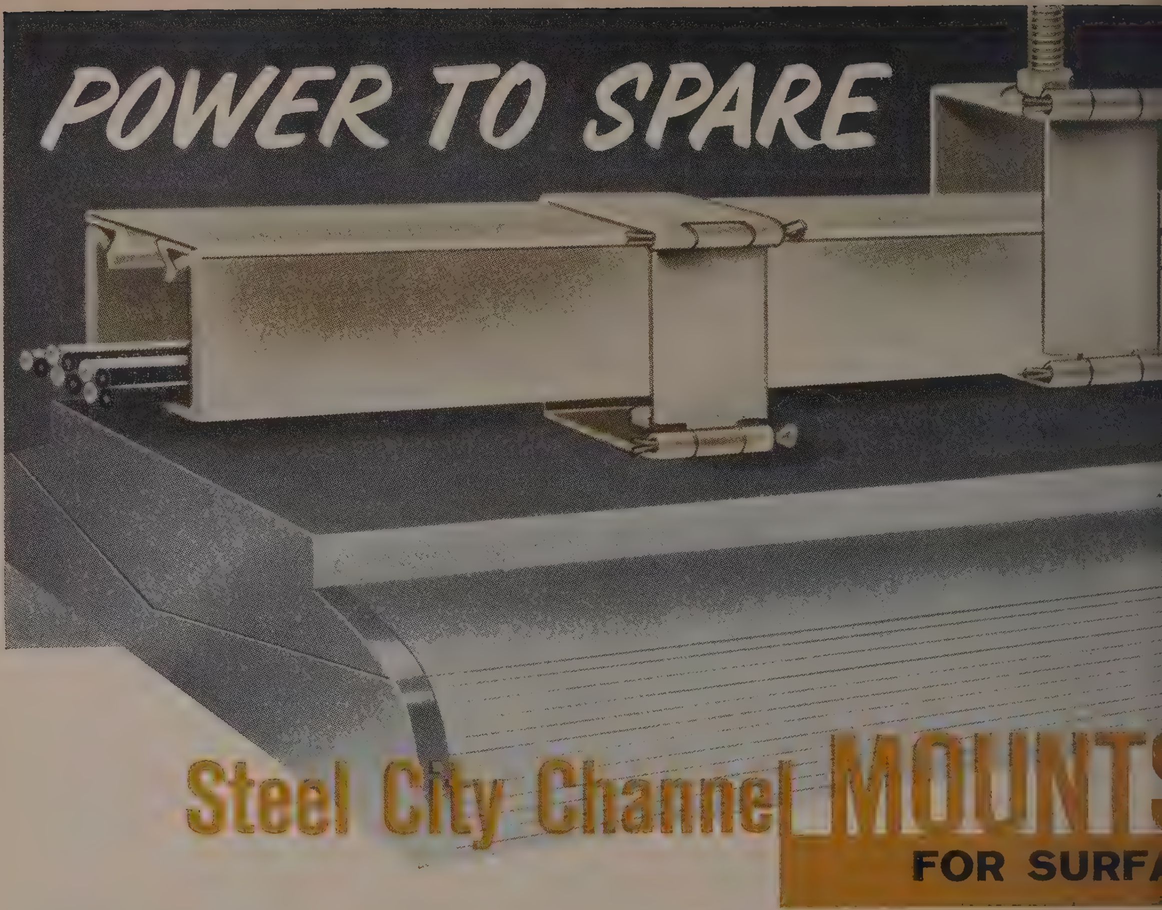


POWER TO SPARE—

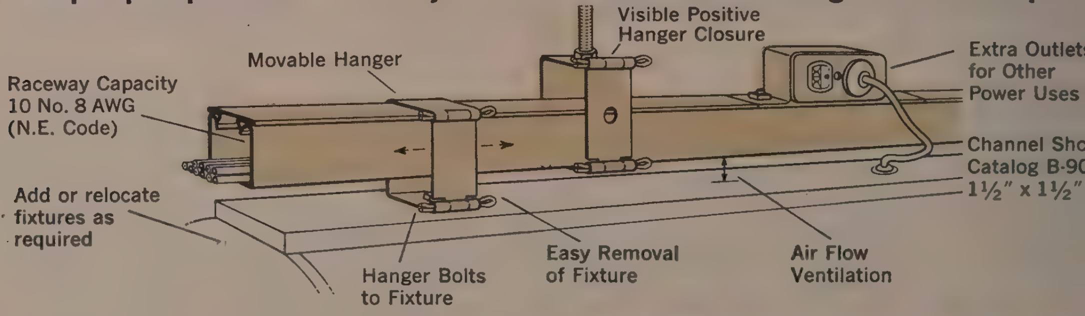
A central wiring distribution channel with conductor capacity that exceeds requirements of any lighting layout and with power to spare for other uses. Here's a Channel that adapts to any interval of structural support—may be dropped to any level where it becomes a rigid platform for fixture attachment. Lighting fixtures may be spaced and fastened anywhere along the Channel System.

Branch lighting circuit conductors are completely enclosed in Channel from panel to fixture. This raceway carries full Underwriters' Laboratories, Inc. approval.

MONEY SAVING FEATURES . . .

- Eliminates cutting and threading of conduit
- Reduces number of hangers
- Uses existing boxes for wiring feeds
- Plug-in method reduces wiring costs
- The greater hanger spacing allows use of e boxes with fewer intermediate hangers
- Pre-wiring of long lengths of channel at ben
- Top mounted receptacles provide outlets for p tools and machinery.

Keeps upkeep down—check easy removal of fixture for cleaning and ballast repair


Visible Positive Hanger Closure
Movable Hanger
Raceway Capacity 10 No. 8 AWG (N.E. Code)
Extra Outlets for Other Power Uses
Channel Sho Catalog B-90 1½" x 1½"
Add or relocate fixtures as required
Hanger Bolts to Fixture
Easy Removal of Fixture
Air Flow Ventilation

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PITTSBURGH 33, PA.

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ANGS & FEEDS the fixtures

SUSPENDED LIGHTING

SURFACE RACEWAY SYSTEMS

LISTED BY UNDERWRITERS' LABORATORIES, INC.

URE ATTACHMENT METHODS

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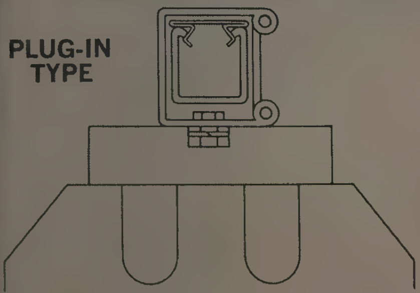
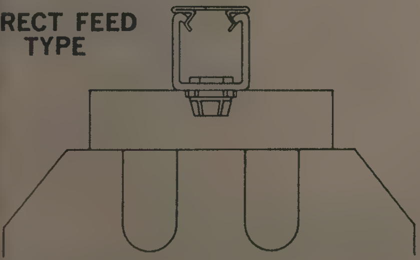


IRECT FEED TYPE



STEEL CITY-KINDORF CHANNELS

Channels of various depths and gauges, for use as surface raceway wiring systems or for fixture support only, are available as standard.

When used as a raceway, the Channel capacities are more than ample for every lighting requirement—up to ten No. 8 AWG conductors (National Electrical Code).

Steel City Channels and accessory fittings are protected by the GALV-KROM finish—an electrogalvanized finish PLUS added protection of zinc chromate. The GALV-KROM process imparts an attractive bronze lustre to the surface which does not require painting.

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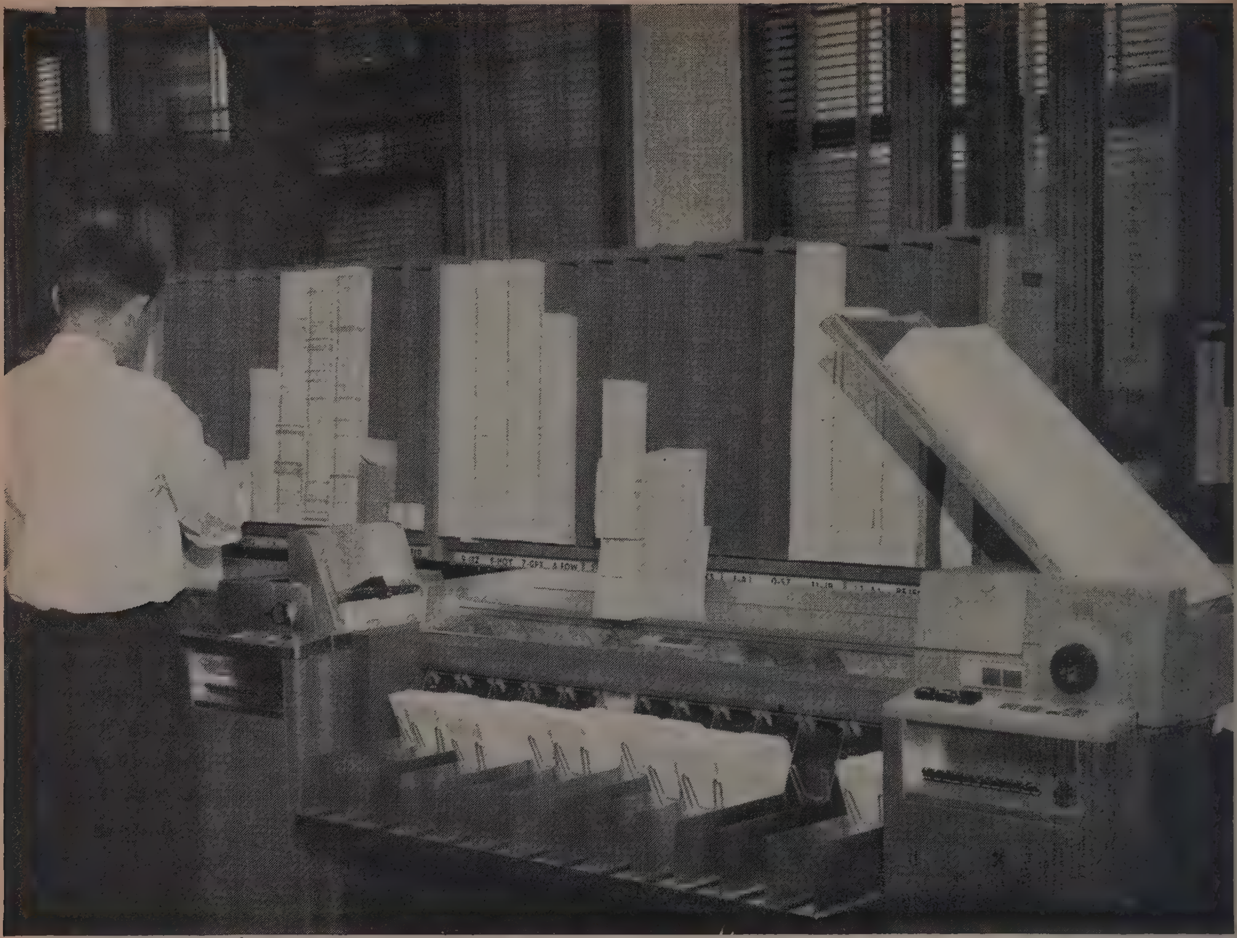

Is standby a big enough word in your power planning?

Specify a Kohler Standby Electric Plant where business depends on "power bookkeeping"

Electricity has automated bookkeeping. Tabulation. Sorting. Addressing. Labeling. Computing. But when normal electric power fails all this beautiful equipment is like help on an extended coffee break, i.e. expensively non-productive.

Solution: Standby power. *Kohler* standby power, because Kohler electric plants deliver exactly as promised. Never over-rated. Always thoroughly tested under five different load conditions before they leave the factory. The plant you install—like all Kohler plants—leaves a permanent written record of factory test performance for future reference.

Kohler plants feature electric cranking through exciter, giving you the fastest automatic starting possible—a prime requisite of standby power. The long service and dependability of Kohler plants are backed up by an extensive network of Kohler distributors and dealers staffed with factory trained specialists.

Kohler standby units range from 500 to 115,000 watts. All meet standards of NEMA, AIEE, ASA, and Canadian Associations. See your nearby Kohler dealer for more information, or write directly to us at Dept. EP-605

(Engineers, see Sweet's Architectural File and Sweet's Light Construction File.)

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s dramatic lighting effects...

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s distinctive decorating touch

you can offer fully variable lighting without having to ilky, over-size boxes.

e new Honeywell Socialite fits into single wall box, con- like regular, single pole switch. Installs quickly in new s or as replacement switch. Adds glamorous lighting s to make a home more inviting.

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and 1000 watt incandescent models available for resi- al or commercial use. Order from your electrical whole- or write *Honeywell, Dept. EC62-69, Mpls. 8, Minn.*

st connect two wires to Socialite ds. It's as simple as installing egular, single pole switch.

2 Mount switch in box and snap-on transparent decorator plate with insert provided or your own insert.

HANDS FULL? ELBOW WILL DO

TAP·LITE

America's custom light switch. Snap-in wiring. Single pole, 3-way and 4-way switches—gang and duplex decorator wall plates.

Wall plates fit both Socialite and Tap-Lite

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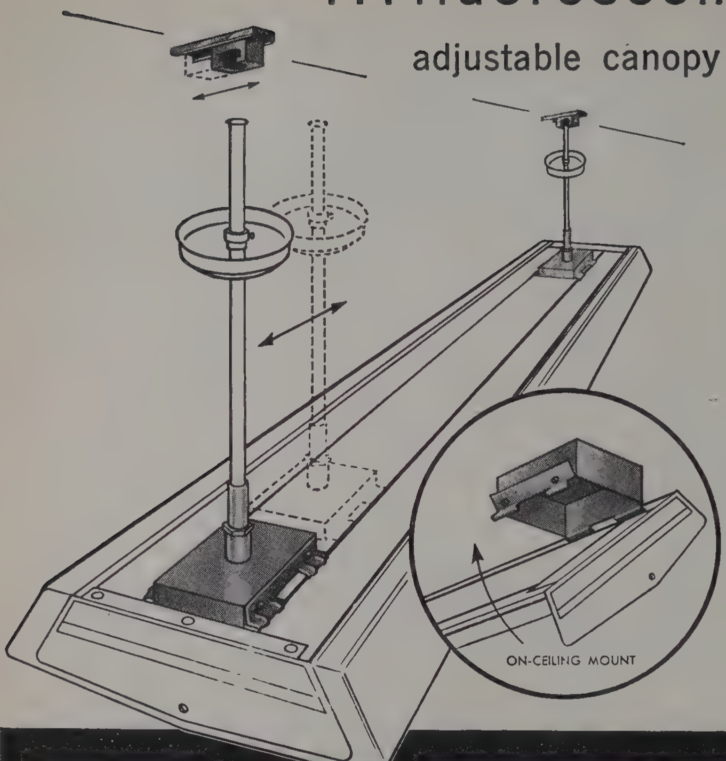
...fluorescent PHOTOMETRIC

adjustable canopy and sliding clamp hanger



Time saved is money saved. From the ceiling strap which permits lateral adjustment up to 1″ in either direction, the hook-on stem which makes one-man installation easy, the threaded stem which makes leveling the fixtures so simple, to the sliding clamp hanger which allows for final adjustments, Wakefield has developed a series of striking features to keep installation costs at a minimum. Note that the sliding clamp hanger is also used for on-ceiling mounting. If you are a Wakefield customer you *know*, if not, try Wakefield and be *convinced*.

Wakefield Lighting Division
VERMILION, OHIO
Wakefield Lighting Limited
LONDON, ONTARIO

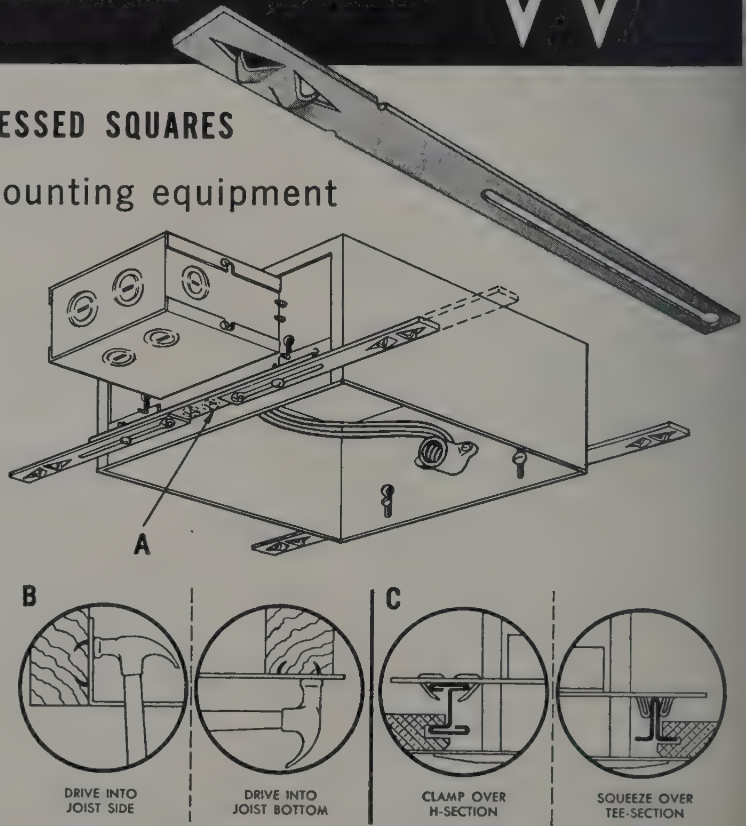
Time Saving Mounting Features by WAKEFIELD CORPORATION

...incandescent RECESSED SQUARES

clinch-cleat adjustable mounting equipment

Look at the illustration. Note that the side rails are stamped for pre-setting to either 14″ or 16″ joist centers (A). Next, you will see how the mounting bar provides for attachment to either the bottom or side of wood joists *without nails, staples or screws* (B). This is our famous Clinch-Cleat Attachment which also provides for mounting in acoustic tile mechanical suspension systems. The Clinch-Cleat clamps over H-sections or squeeze-fits over Tee-sections as shown in the sketches (C).

Art Metal Lighting Division
1814 EAST 40TH STREET, CLEVELAND, OHIO
Wakefield Lighting Limited
LONDON, ONTARIO



ION BALANCE *plus quality and style*

■ By now you know that only Wesix electric heating products have ion balance. And you know, too, that many people in offices, shops and stores as well as thousands of homeowners and apartment dwellers need and want *ion balance*. It's a terrific plus for sales minded electrical contractors and builders.

But what about quality and style—two key points essential to successful installation sales?

Wesix quality was established more than forty years ago. Basic concept, finest components and highest craftsmanship continue to build our reputation. Wesix is still the world's oldest and largest manufacturer of *quality* electric space heating.

And as for style, all we ask is that you and your customers compare the clean, smooth lines, the perfect blending with other room furnishings, and the years-ahead *decorator designs* with other electric heating products.

You'll see why Wesix sets the styles for the industry

Quality, style and ion balance—three selling point that can't miss. Only Wesix has them.

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ELECTRIC HEATER COMPAN
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I want to know more about Wesix products.

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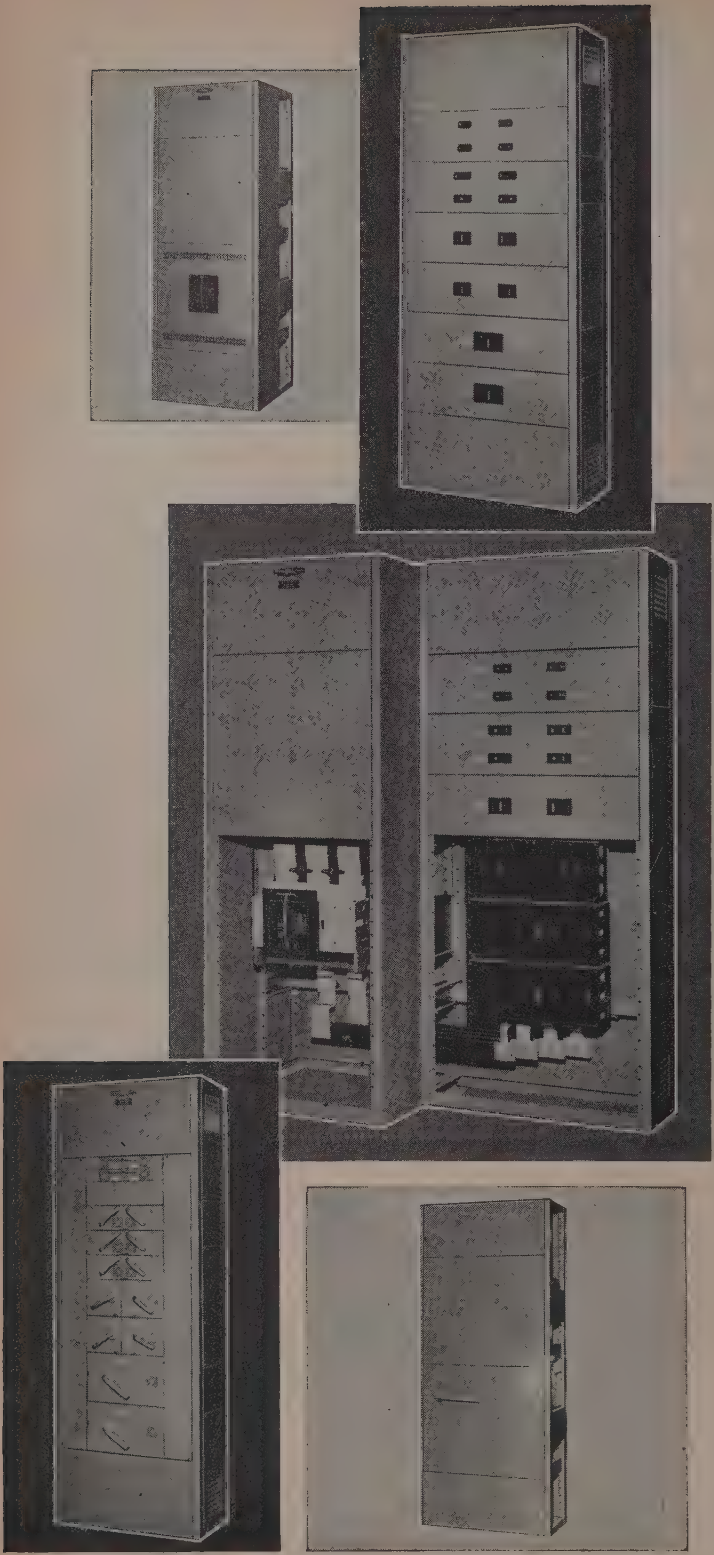

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modular constructed, front connected, pre-engineered

SWITCHBOARDS COMPLETELY BUSSED

I-T-E Uni-Power design permits use of one section, or a combination of cross-bussed sections. Complete factory bussing makes installation quick, easy, and eliminates the assembly of many components. Pre-engineered components meet the requirements of customized jobs.

FUSIBLE OR BREAKER

main service disconnects and distribution sections

Uni-Power Switchboard components are manufactured by highly specialized divisions within the I-T-E corporation and then assembled at I-T-E Area Service Centers strategically located to allow superior delivery. Convenience plus I-T-E quality is yours. Buy the switchboards built for engineers and contractors who are proud of their work. Always specify I-T-E quality.

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I-T-E CIRCUIT BREAKER COMPANY

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TOOLS ELECTRIC

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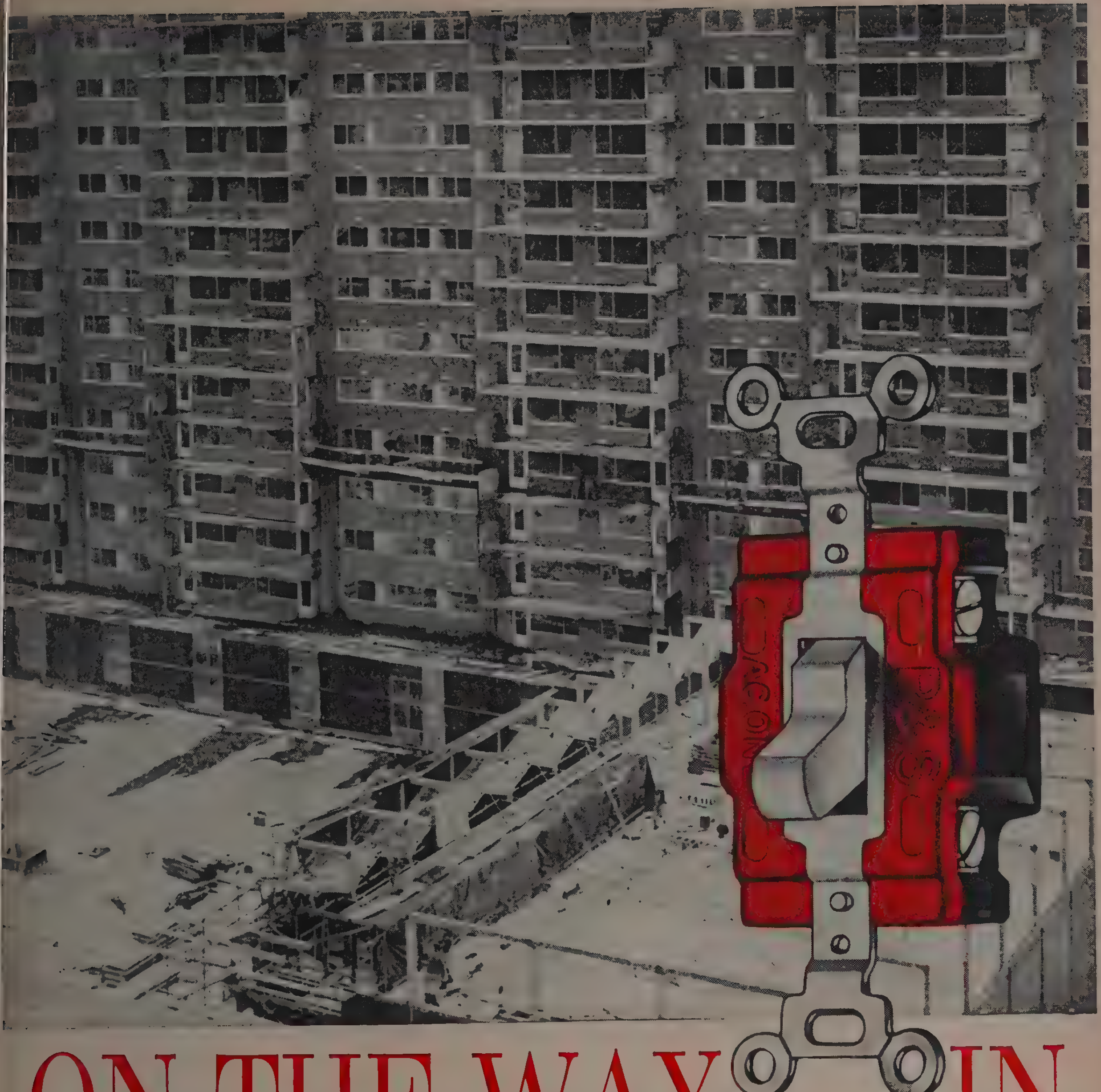

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Steel conduit went in fast fifty years ago—it goes in fast today, with the same tools and procedures everyone is familiar with.

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And it's inexpensive, simple to rewire, and fully compatible with every construction material in major use today.

Before you specify your next job, check with the leading manufacturers of steel electrical conduit, many of whom build their products from Bethlehem steel—EMT from Bethlehem steel sheet; rigid conduit from Bethlehem steel pipe. Or ask your electrical distributor for comparative details.

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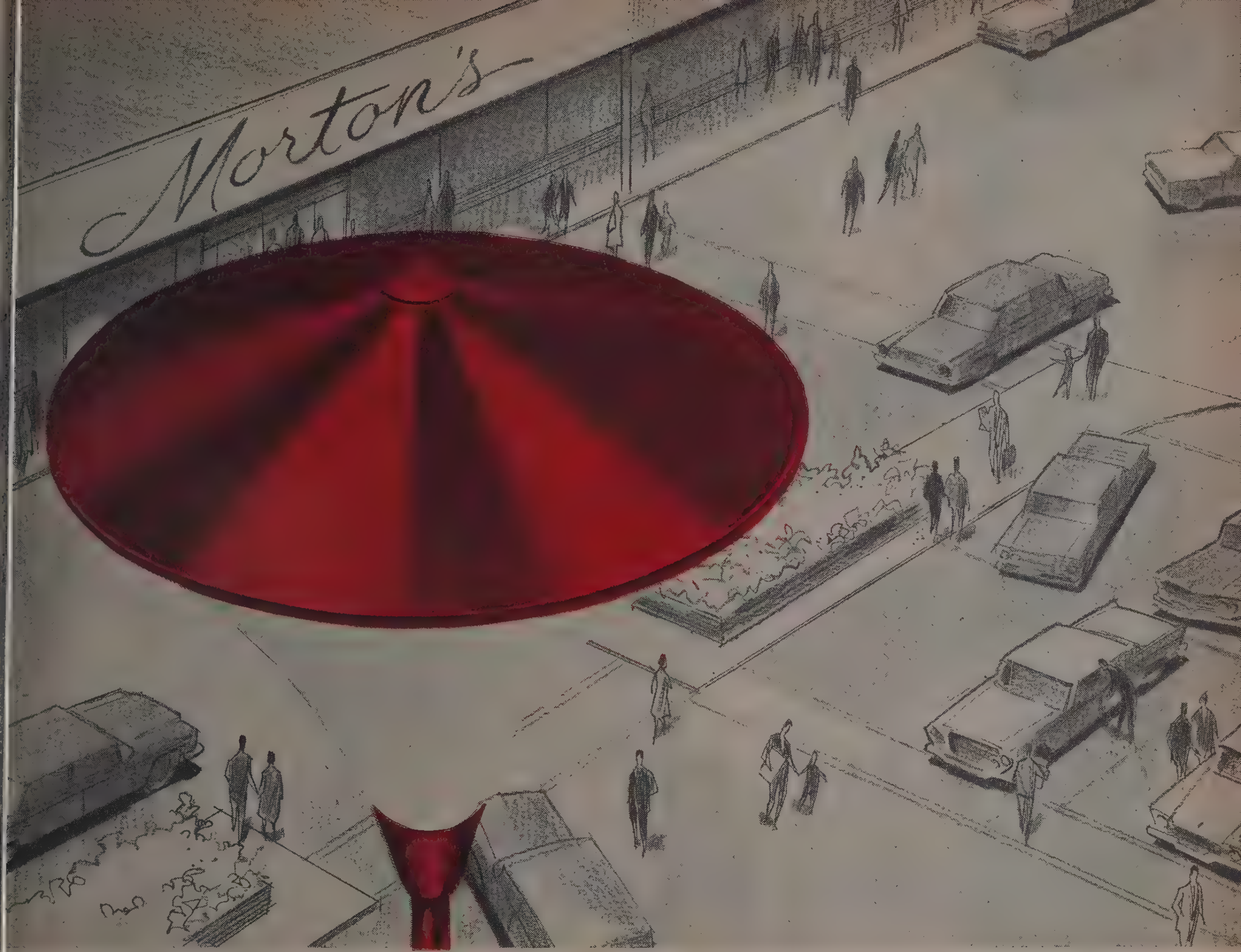
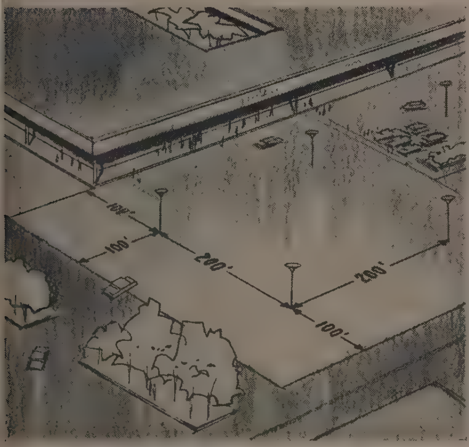


Spectacular new Powerglow luminaire spreads light evenly over a full acre



MORE LIGHT WITH FEWER POLES is yours from the G-E Powerglow unit. 200-foot spacing and 35-foot mounting height put 2½ footcandles on the ground. A specially engineered reflector assures uniform distribution. The large acrylic globe diffuses light to reduce glare. Powerpack design includes ballasts in a completely unitized luminaire.

Now—in line with today's move to new higher lighting levels for shopping center lots—General Electric presents the spectacular Powerglow mercury luminaire and job-matched poles.

This new high-intensity unit delivers *4000 watts* of mercury light . . . spreads an average of 2½ footcandles uniformly over a *full acre.* Six feet in diameter—and available in five striking decorator colors—the Powerglow unit is a real eyecatcher . . . both day and night. It not only attracts customers . . . it helps put them in a buying mood!

For the most spectacular lighting we've ever seen—plus greater efficiency in lighting large areas—get acquainted today with the General Electric Powerglow mercury luminaire. Your local G-E Area Lighting Agent has full information on it, and the *full line* of G-E outdoor fixtures. Or, write for your copy of our new Shopping Center Lighting "Ideabook" to Section 460-18, General Electric Company, Schenectady 5, New York.

Outdoor Lighting Department, Hendersonville, North Carolina

Progress Is Our Most Important Product

GENERAL ELECTRIC

KEEP PACE ELECTRICALLY *with Safety!*

How to select the *right* kind of electrical protection for today's electrical systems

The highest degree of electrical protection available is provided by fuses because they offer the combined advantages of . . .

- **MAXIMUM SAFETY.** The operation of fuses is dependent upon a simple thermal action. When heat from an excessive overload or short-circuit develops, the fusible element melts—and the circuit is open. In a fuse nothing can stick or jam when trouble occurs.

- **LIFETIME DEPENDABILITY.** Fuses are just as safe and accurate 20 years or longer after installation as they are on the day installed. Since they are sealed against effects of dust, fumes, corrosion or age, they require no periodic inspection or recalibration. If a fuse fails it does so on the safe side.

- **HIGH INTERRUPTING CAPACITY.** With electrical network capacities steadily increasing,—a modern protective device must be capable of safely interrupting heavy fault currents now available and be adequately safe to allow for anticipated growth in service demands.

Fuses are available with interrupting ratings as high as 200,000 amps. rms symmetrical.

he Type of Fuse Selected for laximum Efficiency with Safety depends on Service Conditions, Type of Load and Available Fault Current

For all-purpose protection on systems up to 600 amps . . . use USETRON dual-element fuses . . . they

- Protect against heavy short-circuits— ave interrupting rating of 100,000 amps. ms symmetrical.
- Protect against needless shut-downs caused by harmless overloads.
- Protect against needless shut-downs caused by excessive heating of fuses—lesser resistance results in cooler operation.
- Protect motors and equipment against burnout due to overloading or single phasing.
- Protect panels and switches against damage from heating due to poor contact.
- Permit use of proper size switches and panels.

Ask for BUSS Bulletin FIS

If greater interrupting capacity or greater current limitation is required . . . use Buss LOW-PEAK fuses

With Buss LOW-PEAK fuses you get all the advantages of FUSETRON fuses, PLUS...

- An interrupting rating of 200,000 amps. rms symmetrical to protect mains, feeders, branch circuits, motors, controllers, switches, against available fault currents of great multitude.
- Limit let-thru fault currents to exceptionally low values, which reduces stresses and prevents damage to panel-boards, switches, motor controllers, other circuit components.

Ask for BUSS Bulletin LPCS

For the protection of mains and feeders which carry loads above 600 amps . . . use BUSS Hi-Cap fuses

They have an interrupting rating of 200,000 amperes . . . to this has been added great current limitation . . . and long time-lag. Their opening time can be coordinated with that of FUSETRON fuses or Buss LOW-PEAK fuses, so outages can be limited to the circuit on which the fault occurs.

Ask for BUSS Bulletin HCS

For short-circuit protection with limitation of fault currents to exceptionally low values . . . use Buss LIMITRON fuses

On high magnitude faults, Buss LIMITRON fuses will open the circuit before the first peak of available current can be reached—which gives utmost protection to the equipment.

Buss LIMITRON fuses can be used for protection of circuit breakers, mains, branches, semi-conductor rectifiers, and other special equipment.

They can be coordinated with FUSETRON or Buss LOW-PEAK fuses to limit outage to circuit of origin.

In all standard sizes, Buss LIMITRON fuses have an interrupting rating of 200,000 amperes rms symmetrical.

Ask for BUSS Bulletin HLS

For circuits not over 150 volts to ground To safely prevent needless shut-downs without sacrifice of short-circuit protection . . . use FUSETRON dual-element Plug fuses

Their long time-lag prevents useless opening from motor-starting currents or other harmless overloads, yet they protect against dangerous overloads or short-circuits.

Ask for for BUSS Bulletin TCS

To make safe protection remain safe . . . use Buss FUSTAT fuses

Buss FUSTAT fuses are FUSETRON fuses with a Type "S" base so that too large a size cannot be used and bridging or tampering is practically impossible.

For Circuit Protection
Ask for BUSS Bulletin SCPS

For Motor Protection
Ask for BUSS Bulletin SMPS

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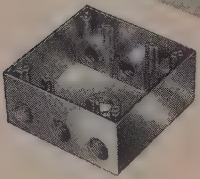
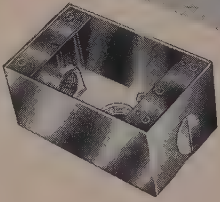

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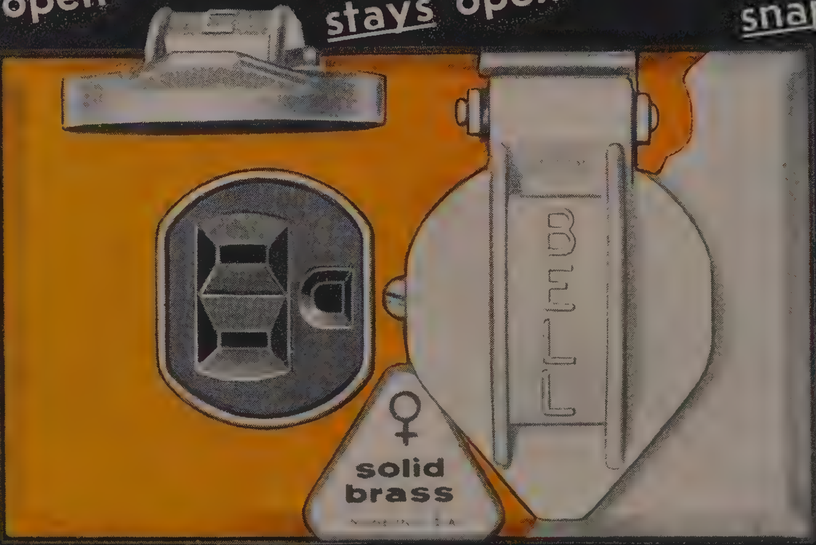

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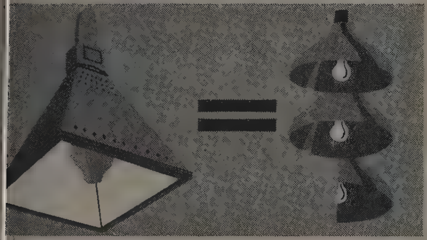
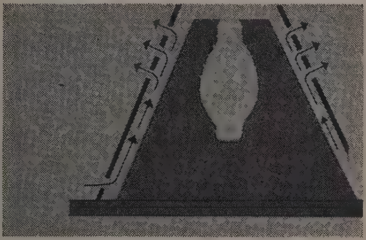
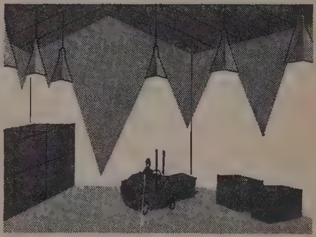
HERE'S WHAT'S IN THE NEW WIDE-LITE INDOOR LUMINAIRE FOR YOU!!!!!



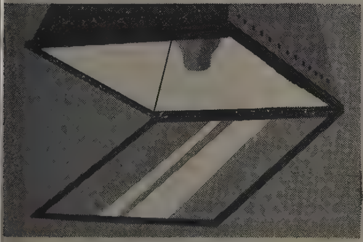
More Light! You get more than twice as much light rom this rectangularly-shaped luminaire as you would rom an incandescent unit of the same wattage. And the ighly efficient segmented reflector system puts this xtra light right where you want it, without shadows or ot spots. What's more, this Wide-Lite fixture's output, nlike fluorescent units, does not drop when room temperature is low!



Longer lamp life! Lamps last longer and their color-correction characteristics are retained better when they are properly cooled. Exclusive Wide-Lite "flue-cooling" sweeps cool air **through** the double-walled fixture body to maintain the most efficient lamp temperature.

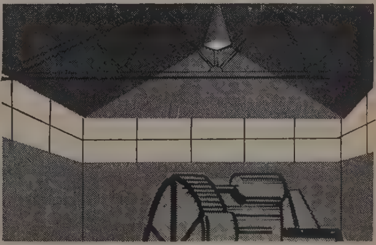


Less glare! Wide-Lite uses a mercury vapor lamp—a big, low-glare light source —to gain a head start in the freedom-from-glare department. But the new Wide-Lite fixture has even less glare than other mercury vapor units. Its lamp is recessed deep in the fixture, and the unique flat reflectors don't **focus** the light. This new glare-free Wide-Lite is a blessing to lift truck operators and others who must look **up** as they work!



Lasting efficiency! A sealed, gasketed lens keeps dirt, bugs and grime off the reflector and lamp to give you continued high light output. The tempered glass lens swings down to permit safe, easy relamping. (This is a feature you won't use often—but it's great when relamping is needed!)

Installation economy! Pre-wired ballasts save as much as **one-half** the installation time on each unit—saving many dollars on the average installation. And, of course, mercury vapor Wide-Lite units make possible big savings in wiring, conduit and switch-gear as compared with incandescent and fluorescent lighting!



Reduced maintenance cost! "Flue-cooling" and heat-resisting Class B insulation transformers protect the ballasts and let you install these new Wide-Lite fixtures without worrying about high air temperatures near the roof or ceiling. Exclusive—only Wide-Lite ballasts carry a **three year** guarantee against failure!

New Wide-Lite indoor luminaires are available for use with 1000 watt, 400 watt or 250 watt mercury vapor lamps. Models are available without pre-wired ballasts when remote ballasts are desired. For more facts, dimensions, and technical data, just send the coupon. Why not do it right now?

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Please send more information about the unique new Wide-Lite indoor luminaires.

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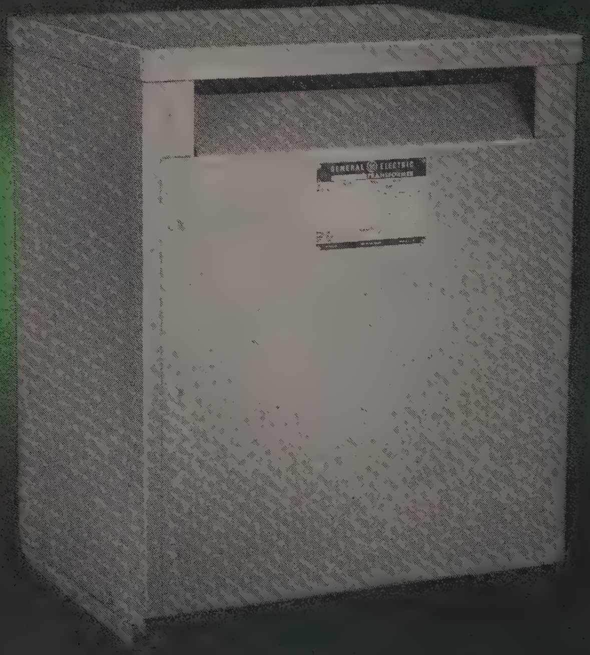
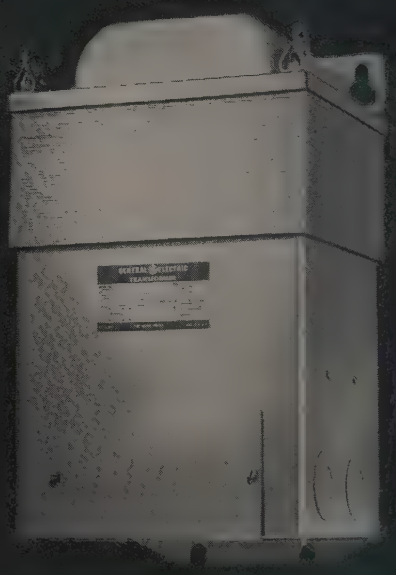
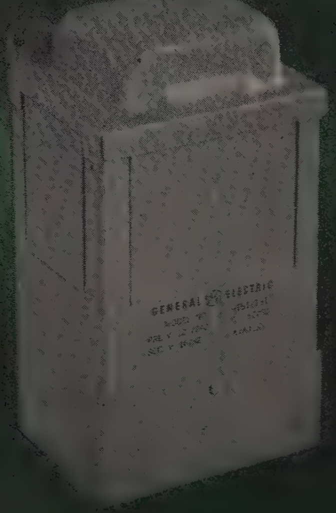
GENERAL ELECTRIC *Announces*



NEW Type H QHT Transformer
37½–167 kva single-phase
30–500 kva three-phase



NEW Type M QHT Transformer
5–25 kva single-phase
3–15 kva three-phase



NEW Type B QHT Transformer
25 va–3 kva

NEW QHT® dry-type TRANSFORMERS

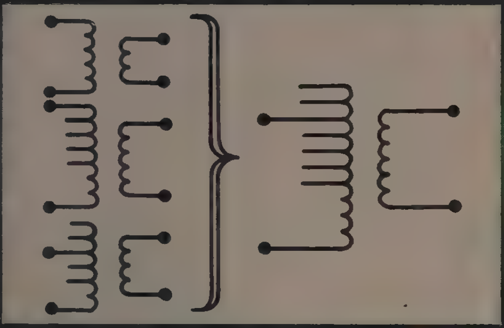
FIRST . . . with all these features:

SOUND LEVELS IN DECIBELS*			
KVA	G-E Average	G-E Maximum	ASA Standard
0–9	37	40	40
10–50	43	45	45
51–150	43	45	50
151–225	43	45	55
226–300	47	50	55
301–500	51	55	60

* Measured per ASA-C 89.1-1961—2.7.3 and 2.7.4.

NEW RATED SOUND LEVELS ARE QUIETER THAN ASA STANDARDS

Larger kva ratings are as much as 10 decibels quieter, and sound levels of smaller ratings are 5 decibels less than former models. As the table at left shows, maximum sound levels of all new QHT units either match or beat the new 1961 ASA standards. And sound levels of the average QHT transformer are even quieter. That's why you can forget about transformer noise when you specify *new* QHT units.



SIX UNIVERSAL VOLTAGE TAPS GIVE 50% WIDER TAP RANGE

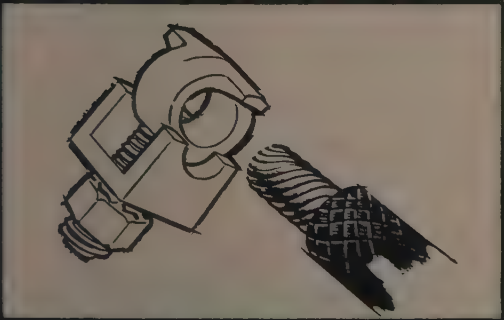
New QHT units 30 kva and up now have six universal voltage taps—four 2½% below normal and two 2½% above normal. This provides a 15% tap range, compared with the usual 10% at *no extra cost*.

As the diagram at left shows, you can now select one transformer rating for a range of voltage levels previously covered by three units. You save ordering time, and you can use the same universal-tap QHT transformer even if your line voltage levels change at some later date.

LISTED UNDER REEXAMINATION SERVICE
UL®
UNDERWRITERS' LABORATORIES, INC.

COOLER WIRING COMPARTMENT MEETS REVISED UL REQUIREMENTS

New QHT transformers meet revised Underwriters' Laboratory specifications for applicable ratings. This U.L. listing means that G-E transformers can be connected with any cable of standard temperature rating including 60 C. You can hook up QHT transformers with low-cost, readily available cable—*unrestricted* by cable compartment temperatures.



CLAMP-TYPE CONNECTORS TAKE COPPER OR ALUMINUM CABLE

It's now easier than ever for you to hook up a QHT transformer. Wiring compartments are roomy and all terminations are located at the bottom of the transformer. They are front-connected for easy accessibility.

These clamp-type solderless connectors on type H units, shown at left, facilitate positive connections and will accommodate either copper or aluminum cable.

GET COMPLETE INFORMATION on the revolutionary new QHT line from your G-E distributor or sales representative. Or write Section 411-20, General Electric Company, Schenectady 5, N. Y.

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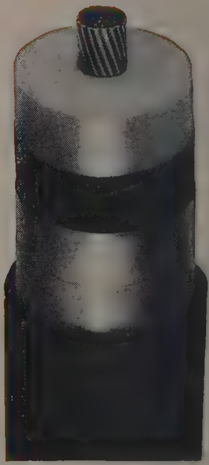

In installation after installation Simplex high voltage polyethylene-insulated power cable has proved itself to be a truly superior product. It combines the advantages of low dielectric loss with high dielectric strength and very high insulation resistance. And it retains these properties under service conditions. Typical applications include direct burial, duct or conduit, aerial and submarine. Write today for complete information.

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EXECUTIVE OFFICES: Cambridge, Mass. • Plants at Cambridge, Mass., Portsmouth, N. H., Westbury, L. I., Monrovia, Calif.

ST YEAR • MAY 1962

ELECTRICAL
CONSTRUCTION
AND MAINTENANCE

Product Selection for Industry Progress

The process of selecting the optimum products and components which are assembled into practical electrical systems is critical and exacting. It takes expert experience and knowledge in a complex and ever-widening field. It should be an essential part of the services performed by the electrical engineer or contractor who bears the responsibility for ultimate performance.

The more alert professional in this industry today is identifiable by the reach and range of the products and methods from which he draws for a deliberate choice. He is broadly experienced but also quick to appraise the new or to reappraise the old in the light of current criteria. But, most important, his selections are skilled, reasoned, thoughtful and objective. They are in effect, a constructive contribution to the building or project under development.

Selection of the components and parts of the electrical system becomes a significant part of the actual technology of practical electrical construction, application and installation. The choice of products in terms of function and correlation should involve the most expert and talented decisions. Unfortunately, selection often bogs down in routine, arbitrary decisions reflecting neither astute technology nor commercial wisdom.

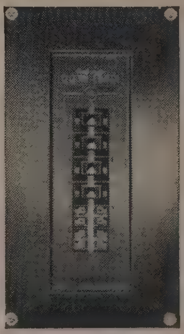
There is no more powerful force in today's economy, and certainly in today's electrical industry, than the buyer. What the engineer specifies or what the contractor or industrial electrical department buys determines what distributors stock and manufacturers fabricate. The buyers' response guides engineering development, inspires marketing and produces the industry's most compelling statistics—sales.

The effective exercise of the buyers' power is too often frustrated by routine decisions such as those made on relatively slight differences in available prices. A selection of the lowest of several prices requires neither talent nor wisdom. Selection from among several values is, on the other hand, a challenge to the highest technical and commercial competence we can bring to bear.

Selection from among alternatives in electrical systems and products is one of the daily tasks of most of the readers of this page. A major share of the editorial contents of this issue is devoted to a manual designed specifically to help in this process. Decision making is rarely easy. But a constructive bias toward industry progress can always be a critical factor. It might well be the decisive one.

Wm. T. Stuart

BOLTED CONNECTION!...BULLDOG PUSHMATIC® CIRCUIT BREAKERS GIVE POSITIVE, FOOLPROOF CONTACT. NO CALLBACKS. BUY TOP QUALITY, ABSOLUTE DEPENDABILITY...BUY PUSHMATIC. SEE YOUR I-T-E DISTRIBUTOR OR YOUR LOCAL I-T-E SALES OFFICE TODAY!!!



Write for your copy of "The Story Behind the Ad".

I-T-E CIRCUIT BREAKER COMPANY
BULLDOG ELECTRIC PRODUCTS DIVISION
BOX 177 • DETROIT 32, MICHIGAN

In Canada: 80 Clayson Rd., Toronto, Weston, Ont.

ELECTRICAL
CONSTRUCTION
AND MAINTENANCE

SELECTING ELECTRICAL EQUIPMENT

A complete manual on the selection of electrical system components—covering construction, operation and application of equipment for electrical distribution and utilization, with emphasis on National Electrical Code regulations and NEMA and UL standards.

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SELECTING ELECTRICAL EQUIPMENT

Effective selection of equipment is vital to success of any electrical installation Every part and device in any system must be carefully selected to meet all of the particular job requirements. Electrical ratings and characteristics must be suited to the design concept of electrical energy circuiting. Mechanical operating elements must be suited to the severity of duty to which they will be subjected. Housings and enclosures must account for method of mounting and must be suited to environmental conditions at the place of installation. And all of these factors must be related to the economics of the particular job to assure maximum return on the dollar investment.

This manual covers general and specific information on selection of a wide range of products used in modern systems for power, light, heat, signals and communications. For each equipment category, the presentation sets forth available types and models, indicating application advantages of each. Data given is based on the latest industry standards and is correlated closely to the National Electrical Code.

The purpose of this manual is to promote effective equipment selection through a higher order of product knowledge among all segments of the electrical construction and maintenance industry. It is hoped that this manual will bring order out of the unavoidable confusion created by the avalanche of product developments over recent years. The greatly accelerated use of electric energy has brought a continually accelerating flow of products into the electrical industry. In more and more cases, products specified during design of a system are obsolete by the time they are installed. The burden on electrical construction people—contractors, engineers, plant electrical personnel and inspectors—to keep up with product developments is truly heavy. This manual is designed to lighten that burden.

Over and above the primary purpose of this manual, to inform the reader and clarify product types, a second aim is to stimulate industry personnel to organize their own approach to increasing product knowledge. The presentation here provides the framework within which anyone can continually expand his knowledge of electrical equipment. This can be the starting point. And there is no end to product knowledge.

LAMPS

Electric light is used for either of two purposes—1) to supplement or replace daylight, especially for utilitarian needs where light is needed to see by; and 2) to create an attractive appearance, or decorative lighting effect.

In selecting light sources for any lighting application, it is appropriate to consider many factors. It is difficult to classify these factors, and to distinguish between engineering factors, on the one hand, or practical physical consideration, on the other. In general, both engineering and physical factors must be considered.

Currently, there are three types of light sources in practical use—incandescent, fluorescent, and mercury. In the category of special application, there are also electroluminescent, black light, and possibly others. There are different types of light sources within each of the three basic types (incandescent, fluorescent, mercury), and typical groups are listed in the table "Types of Light Sources."

Some of the main factors to be considered are given in the table "Influencing Factors in Light Source Selection." It may be noted that all factors relate, either directly or indirectly, to cost. For example, efficiency, rated life, and light output relate directly to cost. Even so, cost per se is not always a final determining factor. Instead, it may be considered as a measure of the over-all practicability of one type of light source versus another, with the individual factors listed still having an influence all their own.

Consider the light output for an individual lamp, for example. This

Types of Light Sources

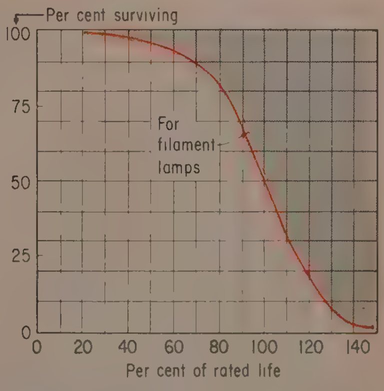
Type of Lamp	Initial L/W* (Range)	Rated Life (Hours) (Range)
Fluorescent		
Preheat	40-65	8,000–12,000
Rapid Start	62-77	10,000–20,000
Preheat-Rapid Start (40-w)	72-77	12,000–20,000
Slimline and Instant Start	47-76	9,000–16,000
High Output (800 ma)	48-75	9,000–16,000
Very High Output (1500 ma)	63-70	7,500–11,000
All-Weather (T10, T10J)	55-66	9,000–16,000
Reflector	.....	10,000–20,000
Circline	42-55	8,000–12,000
Panel	58-60	7,500–11,000
Incandescent		
General Service (A and PS bulbs)	13-22	750–1,000
Reflector Lamps (R, PAR, SB bulbs)	10-18	750–2,000
Quartzline (T3 bulbs)	22-21	2,000
Special Application	.....	50–2,000
Mercury		
100, 175, 250 watt	24-48	12,000
400 watt	45-56	12,000
700, 1000 watt	49-60	12,000
3000 watt	44	6,000

* Based on lamp wattage only, not including watts consumed by ballast or transformer.

ACH TYPE of light source can be further classified, as shown above. Two of ne factors normally used in selection of light sources, "lumens per watt" and rated life," are given in this table for quick reference.

Influencing Factors in Light Source Selection

Factor	Influence on Selection
Color	Spectral quality of light produced affects how objects or areas to be lighted will appear.
Efficiency	Light output in lumens and power consumed provides a measure of the light source efficiency, in lumens per watt (L/W).
Rated Life	Measured in hours of operation, or "burning hours". Affects frequency of lamp replacements, and lamp cost.
Light Output	Measured in lumens. The higher the light output of individual lamps, the smaller will be the number of lamps (and luminaires) required to provide a specific lighting level. A convenient measure of total light produced by a lamp during its rated life is "billion lumen hours" (BLH).
Physical Characteristics	The size and shape of a light source can influence over-all lighting costs, appearance of the lighted system, luminaire brightness, light distribution, and other similar factors.
Electrical Characteristics	Wattages, voltage ratings, electrical operating characteristics, and other similar factors influence light source selection to some extent.
Optical Characteristics	Light sources are of four general types: point, line, area, and "diffuse" point sources.
Cost	Economic considerations include "over-all cost of light," and the cost of the lamp only is usually minor when compared to cost of power consumed, labor cost for replacing burned-out lamps, and other similar items.



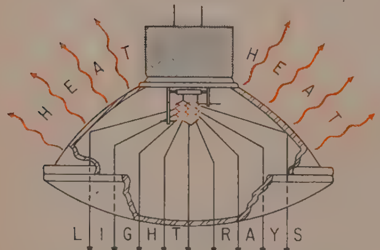
LAMP LIFE data are available for the different types of lamps, and mortality curves such as the one shown above can be used to determine economical group lamp replacement schedules.

factor is used to establish the number of lamps of a specific type that will be required to light an area of a specific size, and also to determine the number of luminaires used. The greater the light output of the individual lamps, the fewer will be the number of lamps required, for a specific lighting level; also, the fewer will be the number of luminaires required. In this example, the factor of light output for a lamp is influencing not only lamp costs, but also luminaire costs, for the entire lighting system. Most of the light source factors therefore have influence beyond the selection of the lamps only.

Light source efficiency, measured in "lumens per watt" (initial and "mean"), is an important factor because of its impact in areas beyond the mere act of the picking out of a suitable type of light source. The "lumens per watt" will have a direct effect upon the amount of electric power consumed, hence on the annual operating cost of the lighting system. Also, the "lumens per watt" will influence the amount of heat generated by the lighting system, hence the amount of air conditioning required to provide a thermally comfortable environment.

Recently a new reflector filament lamp has been announced which reduces the heat inherent in its light beam, by dissipating the heat from the light beam through the special reflector back. This heat removal would thus be a factor in selecting a light source required to light a meat display, confectionery counter, or similar area.

The cost of lamps only is of minor consideration in the cost of producing light. In practice, the



300-WATT PAR-56 REFLECTOR SPOT AND FLOOD LAMPS

HEAT is removed from the light beam of a new type reflector lamp by means of a special reflector coating. This makes the lamp applicable for use over meat counters and similar areas.

Standard Fluorescent Lamps

Lamp Designation	Burnouts Per BLH*	Light Output† Initial Lumens	L/W‡	Approx. Mean Lumens	L/W‡	Brightness (Foot-Lamberts)
For Preheat Circuits (Starters Required)						
F15T12/CW	230	700	46.7	580	38.6	1500
F20T12/CW	146	1080	54.0	915	45.8	1600
F25T12/33/CW	95	1650	66.0	1400	56.0	
F90T17/CW	28	5750	64.0	4700	52.2	2300
For Rapid Start Circuits						
F30T12/RS/CW	82	1850	61.7	1630	54.3	1900
For Preheat and Rapid Start Circuits						
F40T12/54/CW	51	2900	72.5	2600	65.0	2200
F40T12/3/CW	30	3100	77.5	2750	68.7	2350
For Instant Start Circuits						
F40T12/IS/CW	57	2650	66.4	2350	58.9	2000
F40T17/IS/CW	56	2650	66.4	2400	60.0	1150
F36T12/CW	90	1700	56.6	1480	49.4	2100
F48T12/CW	58	2600	66.6	2280	58.5	2100
F72T12/CW	37	4100	73.1	3640	65.0	2100
F96T12/CW	22	5600	75.7	5050	68.3	2100
800 Ma Circuits (No Starters)						
F48T12/HO/CW	45	3500	58.4	2980	49.6	2800
F72T12/HO/CW	28	5550	65.4	4700	55.3	2800
F96T12/HO/CW	17	7900	75.2	6700	63.7	2800
1500 Ma Circuits (No Starters)						
F48PG17/CW	24	6900	62.8	5550	50.4	
F60PG17/CW	19	8900	65.7	7100	52.6	
F72PG17/CW	15	10900	68.2	8700	54.4	
F96PG17/CW	11	15000	70.0	12000	55.8	

NOTE: Above technical data based on published information of one light source manufacturer only. Users should check the technical data of the manufacturer whose products are being considered.

* BLH = Billion Lumen Hours. Burnouts are based on rated average lamp life at 3 burning hours per start (see "Fluorescent Lamp Life" table), and approximate mean lumens at 40% of rated average life.

† Lumen values used are for Cool White lamps. Check manufacturers' published data for other colors of lamps.

‡ L/W—Lumens per watt, based on lamp wattage only.

Approximate Life of Fluorescent Lamps

(Hours of Operation, Under Specified Test Conditions)

Lamp Type	Type Circuit	Hours Per Start 3	6	12	Continuous Operation
F40*	Rapid Start	12,000	14,000	16,000	20,000
	New† SS Lead	8,000	9,000	9,500	12,000
	Lag	10,000	11,000	12,000	15,000
	Old‡ SS Lead	5,500	6,000	6,500	8,500
	Lag	6,500	7,000	8,000	10,000
F40/54	Rapid Start	10,000	12,000	15,000	20,000
	New† SS Lead	9,000	10,000	11,000	13,500
	Lag	11,000	12,000	13,000	18,000
	Old‡ SS Lead	8,000	9,000	9,500	12,000
	Lag	10,000	11,000	12,000	15,000
96″ T12 Slimline		9,000	11,000	13,000	16,000
96″ T12 HO (800 ma)		9,000	11,000	13,000	16,000
All Power Groove (15 ma)		7,500	8,000	9,000	11,000

* Best value for all 40-watt rapid start, and most 40-watt starter-type installations.

† Switch start (starter-type) ballasts manufactured after 1954.

‡ Switch start (starter-type) ballasts manufactured in 1954 or earlier.

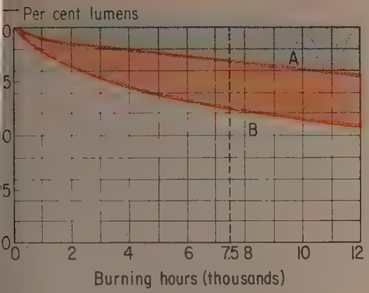
Interchangeability of Fluorescent Lamps

(40-Watt T12 Medium Bipin Types Only)

Type of Lamp	BALLAST TYPE Instant Start*	Rapid Start*	Preheat Start*
Instant Start*	O. K.	Do Not Use	Do Not Use
Preheat Start*	Do Not Use	Poor Starting	O. K.
Preheat-Rapid Start*	Do Not Use	O. K.	O. K.

* These three lamp types all have the same physical characteristics—T12 tubes and medium bipin bases—hence, they are physically interchangeable. However, ballast characteristics vary, and care should be used to prevent installation of wrong type of lamps on specific ballast circuits.

umen Depreciation of Fluorescent Lamps



IGHT OUTPUT of fluorescent lamps de-
reases as the number of hours of burn-
ng increases. Curve A represents per-
ormance of most good quality fluorescent
amps of the more popular types used
or general lighting, while curve B repre-
ents performance of about one-fourth
f the lamp types which are of less effi-
ient design.

ost of the lamp bulbs only averages
bout 10% of the cost of the power
onsumed by the lamps. A cost-of-
ight calculation to determine the
'unit cost of light" of one lamp ver-
us another is therefore useful. The
ollowing formula has been devel-
ped to provide such a "unit cost of
ight," based on "dollars per mil-
ion lumen-hours."

$$\text{Cost} = \frac{10}{E}\left(\frac{P}{WL} + R\right), \text{ where}$$

E = Average lumens per watt throughout life
W = Average watts consumed throughout life
L = Average lamp life, in thousands of hours
P = Net cost of lamp installed in socket, in cents
R = Cost of electrical energy in cents per kilowatt-hour.

Fluorescent Lamps

There are several factors, both
avorable and unfavorable, which
ffect selection of fluorescent lamps
or a lighting installation.

On the favorable side are such
actors as high efficiency, long life,
ow lumen depreciation throughout
ife, low heat output per footcandle
of illumination, high diffusion of
ight output, low operating cost, and
ow unit cost of light.

On the unfavorable side are such
actors as a characteristic cool
(blue-green) color quality, lamps
are large in physical size for the
amount of light produced by each
amp, they require a "ballast" for
operation (which is heavy, bulky,
and consumes additional electric
power), and lamps are sensitive in
ight output to ambient tempera-
ture variations and air drafts.

Light output efficiency of fluorescent lamps varies from about 45 to 70 lumens per watt, including power consumed by the ballasts, and lumen depreciation ranges from about 17% to 25% at 7,500 hours of burning. Rated average life ranges from about 7,500 hours at three hours per start to 20,000 hours for some types when operated continuously (see "Rated Average Life" table).

The low heat output per footcandle results from the high efficiency of the lamp, and is an important factor when considering lighting heat loads that must be dissipated by building cooling systems, especially where high lighting levels of 150 to 200 footcandles and above are involved.

While fluorescent lamps are considered as "line" sources of light, the "line" varies from 1 in. to over 2 in. in diameter. This provides a high diffusion of the light, which is also usually further diffused by light control devices in the luminaire. This factor also makes fluorescent lamps a logical choice where high levels of well diffused illumination are needed for drafting rooms, offices, classrooms, industrial production and assembly areas, supermarkets and similar locations.

The high efficiency of fluorescent lamps also means that power consumption is low, and this leads to low operating cost for the lighting system. This also contributes to the low unit cost of light.

The color quality of fluorescent lamps is characteristically "cool," or lacking in red. This results from the strong blue and green "line spectrum" of the mercury in the fluorescent lamp, and the relative weakness of the light from the activated phosphors in the lamp. Improvements in color quality through use of different phosphors result in the lowering of efficiencies, but where color appraisal is important in the lighted area, the less efficient color-improved lamps may be desirable and practical.

The size and shape of fluorescent lamps dictate the general design and appearance of fluorescent luminaires and make difficult the incorporation of individualness in luminaire designs. The low light output per lamp also means that several lamps are required per luminaire where higher lighting levels are needed. The fact that ballasts are also required to operate the fluorescent lamps means that the luminaire designer must also conceal and support the ballasts in the luminaires, further restricting the design flexibility of fluorescent luminaires.

Notwithstanding these adverse factors, the economies which result from the higher efficiency of fluorescent lamps, from their long life, and from their reduction in heat

Standard Incandescent Lamps

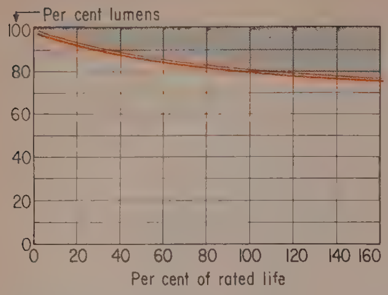
Lamp Description		Burnouts	Light Output‡			
		Per	Initial		Approx. Mean	
Watts	Bulb	BLH†	Lumens	L/W	Lumens	L/W
75	A-19		1,150	15.3	1,090	14.6
100	A-19*		1,750	17.5	1,640	16.4
150	A-23		2,700	18.0	2,500	16.6
200	PS-25	375	3,820	19.1	3,560	17.8
300	PS-30	254	6,000	20.0	5,250	17.5
300	PS-35	225	4,800	16.0	4,450	14.8
500	PS-40	114	9,900	19.8	8,800	17.6
750	PS-52*	65	16,700	22.3	15,500	20.7
1000	PS-52*	46	23,300	23.3	21,600	21.6
1500	PS-52	35	33,000	22.0	28,500	19.0
750	T-24	77	14,200	18.9	13,000	17.4
1000	T-24	56	20,000	20.0	17,800	17.8
500	R-52	71	7,850	15.7	7,050	14.1
750	R-52	48	12,700	16.9	10,500	14.0
1000	RB-52*	35	18,000	18.0	14,400	14.4
550	R-57		8,100	14.7		
800	R-57		13,500	16.9		
1000	R-57		16,300	16.3		
500	T-3	48	10,500	21.0	10,400	20.8
1500	T-3	15	33,000	22.0	32,600	21.7

* Coiled-coil axial filament lamps.

† BLH = Billion Lumen Hours. Burnouts per BLH are based on approximate mean lumens and rated average life.

‡ Lumen values as published by one manufacturer of light sources. Light output for specific lamps should be checked with manufacturer whose product is being considered.

Lumen Depreciation of Filament Lamps



FILAMENT LAMPS decrease in light output from 100% initially to about 82% at full rated average life. Curve shown is average for general service lamps. Rate of depreciation may vary for many reflector type and special application lamps.

Rated Average Life of Incandescent Lamps

Type of Lamps	Rated Life (Hours)
General Service Lamps: Small wattage lamps up to and including 300 wa tts, with medium screw sockets, in types A and PS bulbs	750
General Service Lamps: Mogul-base socket lamps, PS bulbs, from 300 to 1500 watts	1000
Lumiline Lamps: 30, 40, 60 watts	1500
Projector, Reflector and Quartzline: PAR- and R-type lamps, and 500 and 1500-watt quartz-iodine lamps	2000
Extended Life, Special Service Lamps: 25-to 1500-watt lamps, designed for longer life but with reduced light output	2500

Source: Lamp manufacturers' bulletins.

produced by the lamps and ballasts, are of such magnitude that they outweigh the adverse factors, and the popularity of fluorescent lamps continues to increase.

Incandescent Lamps

The incandescent lamp is subject to the same selection criteria as other types of lamps. Thus, it has several factors which show it up as a poor selection for many areas requiring medium to high levels of general illumination. These factors include: low efficiency, short rated average life, high lumen depreciation rate (except for quartz-iodine lamps), and high lamp replacement labor cost—because of the relatively short lamp life.

On the other hand, incandescent lamps remain popular for many lighting applications, and are preferred to other types of lamps for certain specific lighting requirements. These preferences are based on such factors as: good spectral color quality, high light output from a small-sized lamp, excellent light-control features for special lighting applications, and full response to simple dimmer control.

Incandescent lamp efficiencies range from about 15 to 22 lumens per watt, as compared with 45 to 70 lumens per watt for fluorescent lamps. Rated average life varies from 750 to 2500 hours for general service type incandescent lamps (see table). This compares with life ratings of 6,000 to 20,000 hours for fluorescent lamps, and 3,000 to 12,000 hours for mercury lamps. Lumen depreciation occurs at a nearly constant rate to about 82% of initial light output at end of rated life in high quality lamps. An exception to the incandescent lamp lumen depreciation feature is in the quartz-iodine lamps, where lumen depreciation is held to about 2-3% throughout the life of the lamp.

Incandescent lamps are "point source" types of lamps, except for quartz-iodine lamps, which are "line source" types of lamps. Thus the light from the filaments of incandescent lamps can be quite accurately controlled. In general-service lamps, the glass bulb is inside frosted to diffuse the light from the bright filament point. But in reflector and projector type lamps, advantage is made of the point source of light and beam patterns of light distribution are created for a wide variety of special lighting applications. As would be expected, when special patterns of light distribution are required, this requirement overrides other considerations and the specific incandescent lamp meeting the requirements is selected. Filament lamps also lend themselves effectively to a wide variety of luminaire designs, for all types of lighting application. Many incandescent luminaires are of the low cost type, and permit low "first cost" lighting installations. Incandescent units may also be of the ornamental or decorative type.

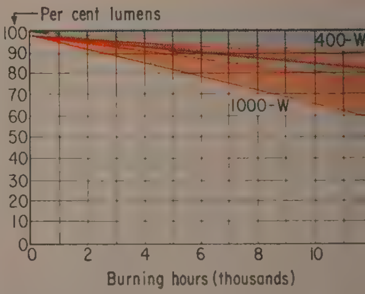
Incandescent lamps remain the popular choice for residential lighting, and for such other applications as the lighting of restaurants, hotels, motels, auditoriums, beauty parlors, theatres, stages, pools and fountains, etc. A major reason for this popularity is that the spectral color quality of incandescent lamps is pleasing to the eye, and flattering to complexions, foods, and people. Incandescent lamps are easily dimmed, and may therefore be used with color filters and dimming controls for spectacular and decorative lighting effects.

Mercury Lamps

The mercury lamp is a gaseou
discharge type of lamp, and pr
duces light as a result of a curren
passing through a gas or vapor u
der pressure. It requires a balla
to control the current through th
lamp. Correct voltage is essenti
for its proper operation, and shou
be kept within 5% of its basic d
sign. The ballast requires a warn
up period of from four to seve
minutes, to permit the lamp vol
age and current to stabilize, an
for the lamp to reach its full lig
output. Power interruptions
more than a few cycles, or seve
voltage drops, will cause the lam
to go out. Restarting of the lam
will require slightly longer than th
original warm-up and starting p
riod. Thus mercury lamps opera
somewhat sensitively, require ba
lasts, and clear lamps produce
light energy in the characterist
mercury yellow-green and blu
violet portions of the visible spe
trum.

These critical gaseous discharg
lamp features may all be considere
as negative factors in the selectio
of light sources for a lighting a
plication. However, mercury lam
also have some advantageous fa

Lumen Depreciation of Mercury Lamps



LUMEN OUTPUT of 400-watt mercu
lamps remains relatively high throug
out life, while that of 1000-watt lam
drops to from 60 to 80% of initi
value.

ors which should also be consid-red.

For example, mercury lamps are sed for general lighting of factories, and of streets and highways, nd for area lighting, floodlighting, ecorative lighting and similar aplications where color quality of the ight produced is not too important. The lamps are available as clear, hosphor-coated, tinted and relector types.

The luminous efficiency of mercury lamps is two to three times hat of general service incandescent amps, and ranges from 35 to 60 umens per watt initially. These amps are also rated at up to 12,000 hours when operated for five or more burning hours per start. The popular sizes of lamps are 400, 700 and 1000 watts. Thus the total inital lumens per lamp range from about 18,000 to 59,500, and up to 132,000 lumens for a 3-kw lamp. This feature of high light output per lamp permits the lighting of relatively large areas with a single reflector unit, and contributes to an over-all low cost per footcandle per sq ft. It also contributes to economical electrical system design.

While the color quality of mercury lamps is too poor to be considered in a lighting application where color discrimination is involved, the phosphor-coated and tinted lamps greatly improve the color of the bluish-green light of the straight mercury lamp. Also, the distinctive color of many of these lamps, especially the yellow lamp, can be used functionally and to advantage in some applications. Further, by combining incandescent and mercury lamps in the same lighting installation and in the same area, two advantages result. First, the incandescent lamps will continue to function when mercury lamps go out due to severe voltage drop or an instantaneous power interruption. And second, the predominantly orange-red light energy of incandescent lamps will supplement the mercury lamp bluish-green light, and greatly improve color quality of resulting illumination.

Standard Mercury Lamps

	Lamp Description		Burnouts Per BLH*	Light Output†			
				Initial		Approx. Mean	
Watts	Bulb	ASA Code		Lumens	L/W‡	Lumens	L/W‡
100	BT-25	H38–4HT	27	3,650	36.5	3,100	31.0
175	BT-28	H39–22KC/W	12	7,700	44.0	7,000	40.0
250	BT-28	H37–5KC/W	7.7	12,000	48.0	10,900	43.6
400	BT-37	H33-IGL/W	4.1	22,500	56.2	20,400	51.0
400	R-52	H33-IDN/W	4.0	22,500	56.2	20,600	51.5
425	BT-37	H17LB/C	5.0	20,500	48.3	16,600	39.1
700	BT-46	H35–18ND/W	2.4	40,000	57.2	34,400	49.4
1000	BT-56	H36–15GW/W	1.8	60,500	60.5	47,000	47.0
1000	BT-56	H34–12KY/W	1.8	56,000	56.0	47,000	47.0
3000	T-9½	H 9-FJ	1.5	132,000	44.0	108,000	36.0

* BLH = Billion Lumen Hours. Burnouts per billion lumen hours calculated, based on approximate mean lumens, and rated average life.

† Light output is based on initial and approximate mean lumens as published by one light source manufacturer. Users should check the technical data of the manufacturer whose products are being considered, for specific types of lamps other than those shown.

‡ L/W = Lumens per watt, based on lamp wattage only.

Rated Average Life of Mercury Lamps

Type of Lamps	Rated Life* (Hours)
General Lighting Service Lamps: PAR-38, BT-25, BT-28, BT-37, R-52, R-57, BT-46, and BT-56 type bulbs (100 to 1000 watts)	12,000
3000-watt T9½ bulb lamp	6,000

* Rated average lamp life is based on 5 or more burning hours per start, with ballasts which meet published specifications, and with lamps operating in a vertical position.

DIMMERS

The use of lighting dimmers is growing, and is undoubtedly being spurred by the introduction of low-cost units for residential applications, which essentially replace the usual wall switch. Dimmers add unlimited flexibility to lighting control, and make it possible to create environmental change, atmosphere and mood, through lighting intensity variation and spectacular color blending. Dimmers are available in a variety of sizes and types, ranging from a simple 500-watt device which installs in a standard wall switch, to large capacity units remotely controlled from a console. Basic types, according to electrical circuit elements, are listed in the accompanying table.

The resistance dimmer is the simplest of all types, and consists simply of a variable resistance in series with the load (see drawing). The voltage drop across the resistance is dissipated as wasted heat. This makes it expensive to operate. Its first cost, however, is small, and it can be used on dc as well as ac circuits.

With the inductance-type dimmer, the voltage dropping phenomenon of inductance is employed The circuit arrangement is similar to that of the resistance dimmer, except that the dimming element is an inductor in place of a resistor, and is also connected in series with the lamp load. This type of dimmer will operate properly only over a rather limited load range. In general, its disadvantages out-

Basic Types of Lighting Dimmers

Basic Type	Features
Resistance	AC or DC operation. Lightweight. Low first cost. High loss High heating. Expensive to operate.
Inductance	Low loss. Low power factor. Noisy. Load sensitive. AC only.
Electronic Tube	Great flexibility in remote control. Versatility in master-control. AC only. Expensive. Complicated circuitry.
Adjustable Auto-transformer Dimmer	Low loss. Moderate cost. Insensitive to load. Wide flexibility for large power loads. AC only.
Saturable Core Reactor, DC Control	Low loss. Great flexibility in remote control. Versatility in master control. Expensive. AC only.
Magnetic Amplifier	Low loss. Good regulation. Flexibility in remote control. Short time constant. AC only.
Silicon Controlled Rectifier	Control is instantaneous. No warm-up period required. Can't be overloaded. Small size. No cooling required. Low voltage control. Linear dimming. AC only. Highly efficient. Stepless dimming.

weigh its advantages, and its use is not generally justified.

The adjustable autotransformer dimmer is a single-winding cylindrical-shaped transformer which produces smooth, flickerless dimming from blackout to full brightness of the lamps. It has excellent regulation, is highly efficient, and hence has negligible heating. It can be operated either manually or motor driven. It may be used for dimming either incandescent or fluorescent lamps. It is insensitive to load variation.

Electronic dimmers are available in four types: electronic (Thyratron) tube, tube-controlled saturable reactor, magnetic amplifier, and silicon-controlled rectifier. All are basically similar in their circuitry.

Thyratron dimmers provide almost instantaneous response to control changes, greater flexibility for remote control, and versatility for mastering or grouping. The tubes require a warm-up period, however, and changes in tube characteristics necessitate constant adjustment.

A new 2-piece dimming unit for incandescent or fluorescent lamps, utilizes the saturable core reactor principle. In this unit, the impedance of a reactor is varied by controlling the amount of direct current fed to a control flux-saturating winding on the reactor core. One part of the unit is a small control pack with a rotary handle, for ready mounting in a standard switch box. This control unit is simply connected to the reactor assembly which can be mounted in any convenient, out-of-the-way place, e.g., in a closet, in the ceiling, etc.

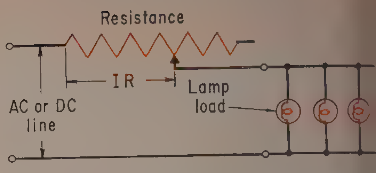
The magnetic amplifier dimmer, making use of new magnetic materials and improved rectifiers, contains various feed-back and compensating windings in addition to the control and power windings. These make it possible to control large amounts of power with very small-sized control circuits.

The controlled rectifier system dimmer is the newest development in dimming. Basically, its circuitry is the same as that of the electronic (Thyratron) tube and magnetic amplifier. It uses silicon-controlled rectifier devices as a means of power control. These controlled rectifiers replace the Thyratron tubes in the magnetic amplifier circuit, and affords all the advantages of the magnetic amplifier and tube-type dimmers, plus the advantages of compact size and minimum maintenance.

The current trend to low-wattage wall-mounted dimmers for use in residences began with a 360-watt autotransformer dimmer which could be installed in the standard 2-in. by 4-in. studded walls of the typical home. Connected as an adjustable autotransformer, it could be used for incandescent or fluorescent dimming. Connected as an adjustable reactor, it could be used for dimming of rapid start hot-cathode fluorescent lamps.

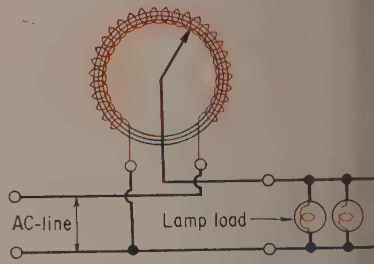
More recently, several makes of dimmers have been announced for residential use. These range from "high, low, off" arrangements to silicon-controlled rectifier units for 500-watt and 600-watt circuits, which are small enough to fit into standard wall switch boxes and provide stepless dimming from full blackout to full brightness. These units are relatively inexpensive, and are ideally suited for light control in homes.

Resistance Dimmer



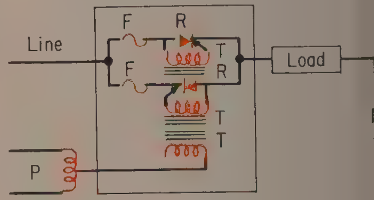
SIMPLEST of all dimmer circuits is tha of the resistance dimmer. Resistance i in series with the lamp load.

Autotransformer Dimmer



VOLTAGE is varied on the transforme principle in the autotransformer dimme circuit, which will operate a wide rang of lamp loads efficiently and withou heating.

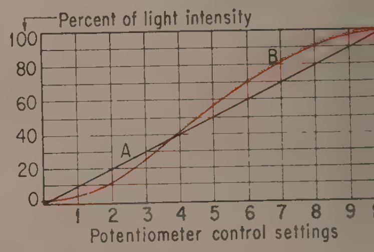
Controlled Rectifier Dimmer



Legend:
F- Protective fuse
R - Silicon-controlled rectifier
T - Control amplifier
P- Dimmer control potentiometer

BASIC CIRCUIT for a silicon-controlle rectifier dimmer is shown. Control inpu is completely isolated from power inpu

Light Output Curve for Dimmer



RESPONSE of light intensity to control c a silicon-controlled rectifier dimmer shown in Curve B. It approximates th theoretically linear response of light i tensity as related to the potentiomete scale, shown by Curve A.

BALLASTS & ACCESSORIES

Fluorescent and mercury lamps are electric discharge devices which cannot be connected directly to an electrical circuit in the simple manner used for incandescent lamps. Instead, they require a "ballast," a device for providing regulated voltage and current for starting and operating the lamps. The electrical design characteristics of this device must match precisely the electrical requirements of the specific lamp it has been designed to control and operate. These requirements vary with the length, diameter and construction of the lamps, and the gases used in the lamps. Thus, for the most efficient and economical operation of a specific type of lamp, the correct type and size of ballast must be selected.

Fluorescent Ballasts

For fluorescent lamp operation, there are different basic types of ballast circuits, each having its own characteristics and features. These include: trigger start, preheat start, instant start (two types—lead lag, and series sequence), rapid start, dimming ballasts, and flashing ballasts. Ballasts are also designed for operation on primary circuits of different voltages and frequencies, with a separate design for each specific voltage and frequency. In addition, ballasts are designed to operate either one lamp, or two lamps, and in certain cases, three and four lamps. Also, the design may involve uncorrected power factor, or high power factor.

The selection of ballasts involves all of the above variables, which must be conformed with the electrical system design characteristics and the specific fluorescent lamp type (or types) which are involved on the specific lighting installation under consideration.

In addition, there are many other important factors to be considered in selecting fluorescent lamp ballasts. A ballast should be chosen which is made by a reputable manufacturer, and which carries a Certified Ballast Manufacturers (CBM) label. This label means simply that the specific ballast design has been tested and certified by Electrical Testing Laboratories, to determine if it meets CBM specifications and/or ASA standards.

Individual manufacturers normally rate their own ballasts for sound, and where quiet ballast operation is a factor, quiet operating ballasts should be selected. Ballast case temperature should not exceed 90°C for full ballast life. Temperature is influenced by design of the luminaire in which the ballast is used, and thus luminaire design becomes an indirect consideration in ballast selection.

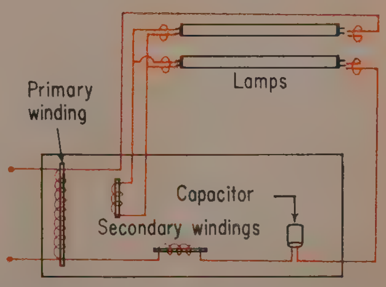
Ballasts are now available with either standard filling compound, or a special type of solid fill material that will not melt and drip under excessive heat sometimes encountered in poor luminaire design. This is an important feature to be considered. Also, because of the heat problem, ballasts may be protected thermally. Three methods are in general use. One method is to fuse the ballast circuit, which protects the ballast against overcurrent, which would cause ballast heating. Another method is thermal protection, in which a heat-sensitive device is put inside the ballast, adjoining the coils, which will break the circuit when overheating occurs, then turn the circuit back on when the temperature drops to a predetermined level. This method permits the problem which is causing overheating to be cleared up and the ballast to be continued in use. The third method is also thermal protection, in which two heat-sensitive devices are used, one adjacent to the coils, and the other adjacent to the condenser. If trouble develops in a ballast or circuit protected by this method, one of the thermal devices will cut the ballast off the line, and the bal-

Data on Typical Fluorescent Ballasts
(For Use On 60-Cycle, 120-Volt Circuits

Lamp Description Number and Type Lamps	Lamp Current (ma)	Line Current (Amps)	Watts Consumed By Ballast	Watts Consumed Per Lamp*
PREHEAT START (Starters Used)				
2-F15T12	330	.32	8.0	19.0
2-F20T12	380	.42	10.0	25.0
2-F30T8	350	.70	17.0	38.5
2-F40T12	430	.85	18.0	49.0
3-F40T12	430	1.30	30.0	50.0
2-F90T17	1550	1.95	38.0	109.0
RAPID START (No Starters)				
2-F30T12	430	.65	16.0	38.0
2-F40T12	430	.80	12.0	46.0
2-F72T12	800	1.80	35.0	102.5
2-F96T12	800	2.15	35.0	122.5
2-F96PG17	1500	3.90	30.0	230.0
INSTANT START (No Starters)				
2-F72T12	425	1.20	25.0	69.5
2-F96T12	425	1.40	25.0	35.5

* Lamp wattage plus proportional watts loss in ballast.
Based on manufacturers' literature.

Rapid Start Circuit for Two-Lamp Ballast



STARTING and operation of fluorescent lamps may be controlled in different ways. As a result, ballasts are made based on different types of circuits. The rapid start circuit is fast becoming the most popular. Other circuits include the preheat start, instant start, trigger start, dimmer circuit, and flashing circuit.

last can be replaced after the trouble is located and cleared up. In selecting ballasts for a lighting application, one of these methods of protection, whichever seems appropriate for the project involved, should be adopted.

Simple resistance ballasts are available for use on direct current in certain sizes and ratings for a limited number of types of fluorescent lamps. Also, specially designed ballasts permit certain types of fluorescent lamps to be used with dimmers, or with flashers.

Mercury Ballasts

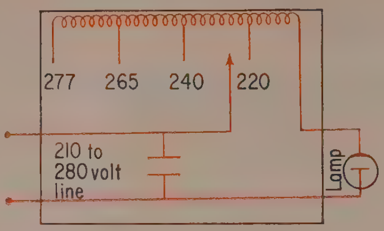
Transformers and reactors are available which have been specifically designed for converting circuit voltages to meet mercury lamp operating requirements. There are types for both indoor and outdoor use, and for standard multiple circuits of various voltages—such as 115, 230, 277, 460 and 520 volts, also for series circuit operation. Transformers are usually of the single-lamp type, although two-lamp types are also available for the popular 400-watt size lamp.

Correct voltage is essential for proper operation of mercury lamps, as wide variations in voltage have a severe effect on lamp performance. Good practice is to keep voltage variation within 5%. To help meet this problem, constant wattage type transformers which regulate lamp wattage, lamp current and light output within plus or minus 2%, regardless of wide line voltage fluctuations, have been made available.

In selecting mercury lamp transformers, it is important to keep the above factors in mind, also to select a transformer designed specifically for the size and type of mercury lamp involved. It is possible to obtain a complete transformer, including its metal housing, or a core and coil assembly only. Also, the complete units in housing can be selected for any of a variety of types of mounting. These include: pole top, aerial mounting, or wall mounting, bracket arm assembly, special hanger brackets for pole mounting, conduit suspension, etc.

Through general practice over the past several years mercury lamps have been accepted for use in outdoor floodlighting applications, such as parking lots, gasoline service stations, building floodlighting, and for use in the lighting of streets, highways, bridges, tunnels, viaducts, docks, marinas, etc. Also, mercury lamps are accepted as a standard method of indoor lighting in medium- and high-bay industrial areas.

Single Lamp Transformer for 400-Watt Mercury Lamp



MERCURY lamps may be operated by any of several different circuits, each circuit having its own advantages and disadvantages. Circuits include: high reactance, series capacitor, regulated output, inductive, two lamp-lead lag, series circuit with individual lamp transformers, and series circuit without lamp transformers.

Lighting Accessories

While fluorescent and mercury lamps require "ballasts" in order to control and regulate the operation of the lamps, all types of light sources require wiring equipment accessories for their practical operation. These include sockets, lampholders, starter switches, etc.

For incandescent lamps, sockets of various types, sizes, materials and construction are available. The popular types are: bayonet candelabra—single and double contact; medium prefocus; screw shell—candelabra, intermediate, medium, three-contact medium, admedium, mogul, three-contact mogul; and mogul prefocus. For low wattage applications, brass shell sockets are used, but for base-up burning applications and large mogul-base lamps, porcelain sockets are preferred. The porcelain sockets may be installed in an outlet box cover, or in steel, brass or aluminum shells provided with pendent or side outlets, threaded.

Fluorescent lampholders are available in a large assortment of methods of mounting, sizes, configurations for the various lamp bases (miniature bipin, medium bipin, single-pin, recessed double contact, mogul bipin, 4-pin, etc.), and turret arrangements. In general practice, luminaire manufacturers equip their luminaires with the proper lampholders and fitting required for the fluorescent lamps for which the units are designed. Thus selection of these accessory devices is not a problem, except to be sure that the proper types are supplied with the luminaires for the lamps which are to be used.

Mercury lamps are designed for use with mogul screw base lampholders, and these are normally supplied by reflector manufacturers as part of the reflector units.

Luminaire Devices

Incandescent and fluorescent luminaires use various materials for controlling or diffusing the light from the lamps. In many designs, the user or specifier has a choice in these materials. For example, in a weatherproof incandescent floodlight, the glass lens cover is available in clear or diffusing glass, or may be had for medium or wide beam spread, etc. Also, various colors of lenses are often available, for color lighting applications. Here it is important that the glass be of the heat-resisting type, and that the color roundels have "purity" of color, for best lighting results.

In fluorescent luminaire designs,

Data on Typical Mercury Transformers

Lamp Type and Watts (No.)	Primary Voltage	Open Ckt. Voltage	Input Watts
H37– 5— 250 (1)............	105/115/125	250	275
H33– 1— 400 (1)............	105/115/125	220	450
H33– 1— 400 (1)............	250/265/277	220	450
H33– 1— 400 (1)............	220/240/265/277	Same as Line Volts	420
H33– 1— 400 (2)............	105/115/125	220	875
H33– 1— 400 (2)............	420/460/500	220	875
H35–18— 700 (1)............	460	Same as Line Volts	740
H34–12—1000 (1)............	220/240/265/277	Same as Line Volts	1050
H36–15—1000 (1)............	460	Same as Line Volts	1030

different types of diffusing and shielding devices are usually made available for each luminaire type. These usually consist of plastic diffusers (vinyl, acrylic, prismatic), glass (diffusing, surface textured, prismatic), or metal or plastic louvers. Metal louvers may be either white enameled steel, or aluminum in white, diffuse, or semi-polished surfaces, and of varying configurations and cell sizes. Plastic louvers are also available in a wide range of configurations and design patterns.

In selecting the shielding or diffusing media, consideration should be given to lighting efficiency, ease of maintenance, brightness control in the direct glare zone (45° to 90° from vertical), and appearance, both lighted and unlighted.

LUMINAIRES

In selecting the luminaires and lighting equipment for any lighting system, regardless of the end use application, the first consideration is one of engineering aspects. The lighting system must provide the proper quantity, quality and light distribution patterns needed for the specific lighting requirements involved. Otherwise, the lighting system will not solve the specific lighting problem satisfactorily.

Some of the principal factors in evaluating luminaries are listed in the table "Selection Factors for Recessed Luminaires." It should be noted that most of these factors also apply generally to all types of luminaires, regardless of type of mounting. Thus this discussion will cover all of the factors involved in selecting luminaires and lighting equipment, without regard to its generic classification.

The first decision normally made in selecting lighting equipment for any application is that of the type of light source to be used. Generally, existing practice can be relied on in making this decision. However, it is still a good idea to make some preliminary studies in which one light source is compared with another, in order to determine the relative first cost and operating cost of the various lamps, and other relative advantages of each type of lamp.

For example, current general practice is to use fluorescent lighting in general office areas, drafting rooms, school classrooms, low-bay industrial areas, banks, and for general lighting in stores, etc. A major reason for this is the inherent high efficiency and relatively satisfactory color quality of fluorescent lamps for these areas.

It is also current general practice to use incandescent lighting in homes, hotels, motels, restaurants, cocktail lounges and bars, reception rooms, and similar areas. The color quality of incandescent lamps, which is characteristically warm and cheerful, resembling that of a flame or torch, is ideally suited to these areas, and psychologically appropriate. Lighting efficiency, or light output per watt of electric power used, is relatively low, about one-third that of fluorescent lamps. Thus color quality of the light produced is considered to be more important in these areas than efficiency, or economy.

Mercury lamps are considered standard practice for industrial lighting, especially for medium and high bay areas, and for outdoor area and sports lighting applications. Mercury lamps are almost as efficient as fluorescent lamps, and produce a high light output from a relatively small lamp. The color quality is not considered as good as that of incandescent or fluorescent, but is generally satisfactory for industrial production areas.

The amount of light needed for various seeing tasks and types of occupancy, for maximum visual efficiency, is usually greater than is economically justifiable. However, the Illuminating Engineering Society has developed minimum recommended footcandle lighting levels for most lighting applications, which are considered practical. In actual practice it is therefore recommended that the IES recommended lighting levels be used as a minimum quantity of light to be installed in any area, and that higher lighting levels be installed to the degree that they can be justified. Having established the lighting level, and the type of light source to be used, it is now a simple matter to calculate the total light output (total lumens) required for a specific area, the number of lamps needed, and subsequently to determine the type, size, light distribution, method of mounting, and other

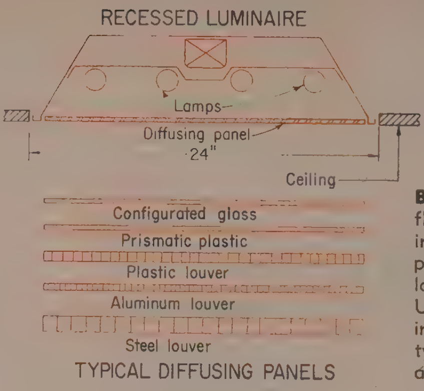
Selection Factors for Recessed Luminaires

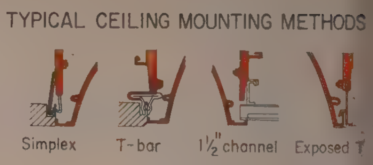
Factor	Description
Light Source	Type, number, and size of lamps.
Light Output	Initial lumens.
Size of Luminaire	Size of unit (inches), including width, length and depth.
Housing	Type of material, gauge of metal, construction features, mechanical rigidity.
Panel Frame	Material and construction of panel frame, or door. Hinged or lift-in? Concealed hinges and catch?
Light Control	Type of control device — diffusers or louvers (shields). Glass, plastic, metal.
Accessories	Type of ballast, lampholders, sockets, wiring, etc.
Maintenance	How is luminaire cleaned and relamped?
Finish	Rustproofing, final finish.
Appearance	Lighted, and unlighted. Range of brightness contrast when lighted.

similar features of the luminaires needed to provide the quantity and quality of light desired.

At this point of the design procedure, the next step is to consider the many types of luminaires available, and to select the specific type of luminaire which will meet all of the technical and aesthetic requirements which may be involved.

Typical Details of Recessed Fluorescent Luminaires





BASIC COMPONENTS of a recessed fluorescent luminaire consist of a housing, wireway, reflector, light control panel (diffusing, refracting or shielding), lamps, ballast, and wiring accessories. Units usually come equipped with mounting arrangements for one of the various types of ceilings, and should be ordered accordingly.

Recessed Fluorescent Luminaires

When end use application and economic considerations indicate that recessed fluorescent luminaires would meet lighting requirements and aesthetic problems satisfactorily, the problem of luminaire selection reduces to a simple check list procedure.

First, it should be determined that ample space will be available in the suspended ceiling plenum for installing recessed units. If obstructions do exist in this space, such as beams, air ducts, sprinkler pipes, and other mechanical and structural elements, it should be determined if recessed luminaires can be located on a suitable spacing arrangement so that they will not interfere with the obstructions. If this is impossible, it should be determined if the suspended ceiling can be dropped further, to accommodate the luminaires. Finally, if this is impractical, it may be necessary to use surface-mounted luminaires.

For those installations where space is available for recessing the luminaires, the next step is to decide on the physical size of unit to use. The number, type and size of fluorescent lamps required per unit area of space to provide the desired lighting level will control this decision of physical size of luminaire, to a considerable extent. Current trends are to larger units. Up until recently, standard practice has been to use 12-in. wide troffers, normally equipped with two rows of 430-ma lamps, and with troffers installed in continuous rows. More recently, the trend has been to 24-in. wide luminaires, usually 4 ft long, and arranged for modular construction with one unit per building module. Units may be equipped with two, three, four or six lamps, which provides considerable flexibility in lighting level control.

Next factor to consider is luminaire construction. The housing should be made of steel of not less than 20 gauge metal, and so constructed that it is completely rigid. Entire housing should be rust-proofed, and suitably finished. Light control devices should be selected which will provide light distribution and brightness control, depending on the number and brightness of lamps, appropriate for the installation being considered. If louvers are selected, they should be completely rigid—either metal or plastic—and held securely in place in a rigid metal frame which is hinged or otherwise constructed for easy removal for cleaning and relamping. Plastic or glass diffusers, if preferred, should also be similarly mounted.

All ballasts should be of the high power factor (90% or above) type and all lampholders, sockets, wiring, etc. should be UL-approved. Entire luminaire should meet the requirements of the National Electrical Code.

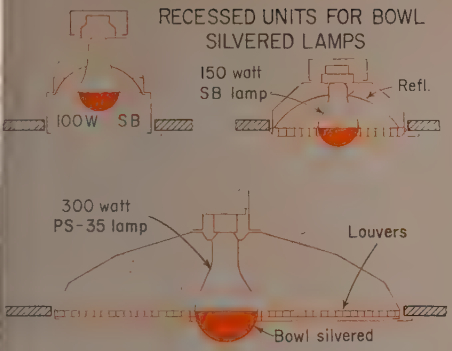
Finally, the appearance of the luminaire should be acceptable, either when lighted or unlighted. This means that the range of brightness contrast should be within acceptable limits, as well as of a pleasing general appearance.

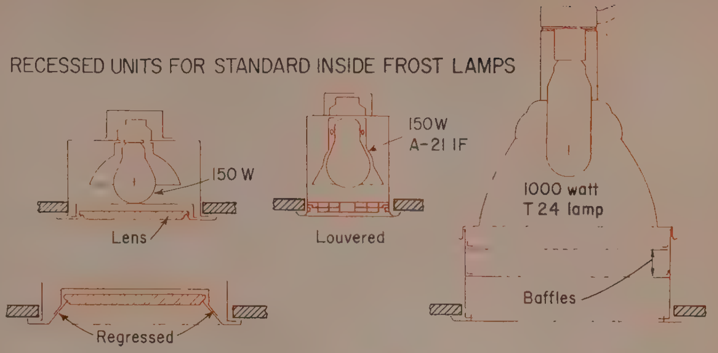
A recent trend in recessed fluorescent luminaire lighting is to combine the luminaire with air conditioning supply outlets or return grills. This practice has developed as a result of the need to locate air conditioning supply outlets at the same location that is appropriate for luminaires. Also, air ducts and lighting units can often be integrated effectively to conserve space in ceiling plenums. When integrated air conditioning-lighting units are considered appropriate, the luminaires and air conditioning system must be compatible; that is, it must be possible to work the two together. Manufacturing practice consists of an air-handling equipment manufacturer and a lighting equipment manufacturer teaming up together to produce a combination air-handling luminaire and an air valve assembly which are compatible, but which is not compatible with other equipments. Different designs of air-handling troffers, each design being based on certain specific technical principles, are currently available. Each design should be carefully studied for its specific advantages and benefits, and a selection made accordingly.

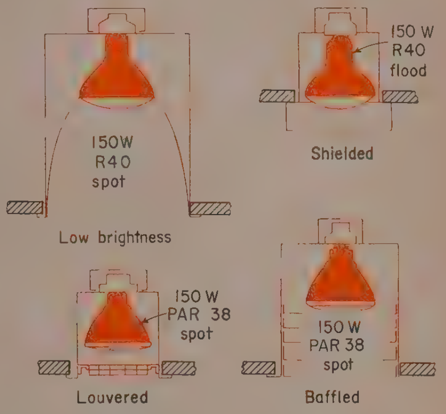
Recessed Incandescent Luminaires

Incandescent lighting remains popular for many contemporary lighting applications, notwithstanding the fact that fluorescent lighting produces from 2½ to 3 times as much light per watt of power consumed. There are three principal reasons for this continued popularity: 1) the color quality of incandescent light is psychologically pleasing to most people; 2) incandescent lamps use filaments which are, within practical limits, either "point" or "line" sources of light, and makes possible accurate control of the light produced; and 3) the quantity of light from a single lamp can be varied over a wide range, up to 1500 watts, or 33,000 lumens, from a single standard lamp bulb (special application lamps range upward in size to 5,000 and 10,000 watts). Other reasons include the fact that no special auxiliary equipments are needed to operate an incandescent lamp, the lamp operates directly from a simple lampholder connected directly into an electrical circuit, and burned-out lamps can be replaced

Typical Recessed Incandescent Luminaires







RECESSED DOWNLIGHTS FOR REFLECTOR LAMPS

FILAMENT lamps with their point source of light permit accurate control of the light, and are popular for recessing. A wide variety of recessed units are available, but all follow a simple basic design pattern, similar to the types shown.

by any non-technical person, such as the porter or an unskilled workman.

Lighting equipment and light source manufacturers have both been alert to develop incandescent lamps and luminaires which would meet the new demands imposed by building construction trends in recent years. As ceiling heights have decreased, and trends have developed to recessed equipments in suspended ceilings, the manufacturers have developed appropriate recessed incandescent luminaires to meet the trends. Today there is a broad range of equipments of all types, for different types of light sources, for mounting in different types of ceiling construction, with all types of light control and light shielding devices, for a broad range of lighting distribution patterns, for use of color in a variety of ways, and equipped with special installation, cleaning and relamping features.

In selecting recessed incandescent luminaires for a specific lighting application, the first step is to determine how much light is needed, and the type of light distribution which is required for this specific application. Then the type, size and number of lamps required per unit can be determined. Generally, only one lamp is used per luminaire, but any combination may be developed where needed for a special application.

The type and size of lamp selected will govern the size and shape of the housing. The ceiling construction will determine the type of mounting detail needed for recessing the luminaire. The type of light distribution pattern needed will control the selection of the control devices—prismatic or diffusing glass, metal louvers, reflector contour, etc.

Other factors in selection include that of type of material and gauge of metals used in the housing, construction features that influence rigidity of the unit, cleaning and relamping features, installation features, and appearance of the unit when installed, both when lighted and when unlighted.

Surface-Mounted Luminaires

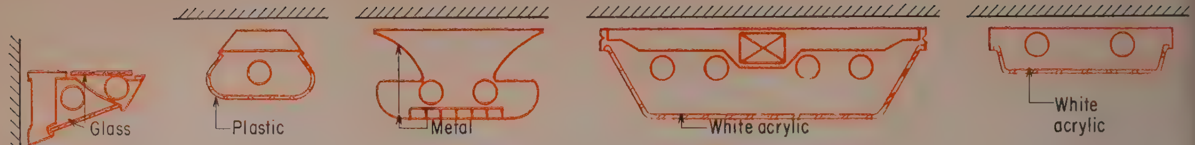
Luminaires which are installed directly on the ceiling, wall, or columns are generally referred to as surface-mounted, or ceiling luminaires, and as wall brackets. There are literally hundreds of different types, designs, shapes and sizes available today, and this type of unit has been popular for the entire history of electric lighting. Current designs are for both fluorescent and incandescent light sources, and may be utilitarian or decorative. If designed to produce light for seeing economically, the units usually employ fluorescent lamps. However, where accurate light control is needed, or when a decorative lighting device is desired, the designs usually incorporate incandescent lamps.

Essentially, surface-mounted luminaires serve the same function as recessed luminaires, except that they are designed to be attached to the surface of the ceiling, or wall, rather than to be recessed in the ceiling. Contemporary designs include both individual units, and continuous row equipment.

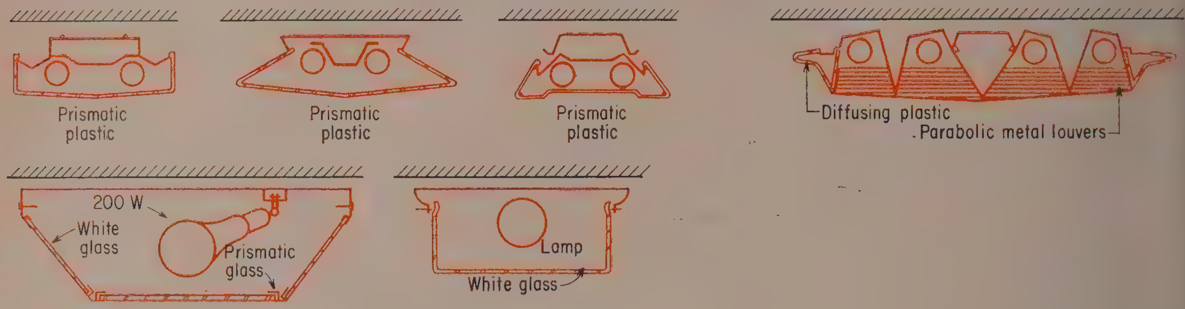
The same factors should be considered in selecting surface-mounted equipment as when selecting recessed luminaires, except for method of mounting. The need for rigid construction is even more important, since the units are usually attached to the ceiling in one or two locations only, whereas recessed units are supported in a rigid frame attached directly to the ceiling construction.

The National Electrical Code prohibits the installation of fluorescent luminaires directly on combustible, low-density, cellulose, fiberboard ceiling materials, and requires that the luminaires be spaced at least 1½ in. away. However, the Underwriters Laboratories Inc. have approved certain surface-type fluorescent luminaires, in combination with certain specific types of ballasts, for use on these low-density

Typical Surface-Mounted Luminaires



FLUORESCENT CEILING LUMINAIRES



INCANDESCENT CEILING LUMINAIRES

types of ceilings. Thus when a surface-mounted luminaire installation is indicated, and the ceiling is of the combustible low-density type, only those specific luminaires which meet the NE Code and UL requirements should be used.

Because of the greater concentration of heat in incandescent luminaires, caution should be used in selecting incandescent units for direct surface mounting, to be sure that the design and construction is such that hot spots do not occur within the unit which might be considered as hazardous.

Appearance of the luminaires, both lighted and unlighted, becomes of even greater importance in the selection of surface-mounted luminaires. Also, spill light from the lighted units should not create any unduly bright spots on the ceiling.

Suspended Luminaires

When ceiling heights in building structures will permit the use of suspended luminaires, it is possible to use indirect and semi-indirect lighting. In many areas, this type of lighting offers some advantages, primarily in increased lighting comfort through careful balancing of brightness contrasts between luminaires and the lighted ceiling above. The trend in building construction over the past few years, however, has been to lower ceilings in most commercial structures, and this precludes the use of suspended type luminaires in these structures. The principal potential today for suspended luminaires is in the relighting of older structures where higher ceilings exist, and in the lighting of industrial plants where higher ceilings are still needed for machinery, use of cranes, etc.

In general, the same rules apply for selection of suspended luminaires as for recessed and surface-mounted equipment. Luminaires should be selected which are made by a reputable manufacturer, and by one that has a reputation for making a quality product. Fluorescent luminaires should be equipped with ballasts which carry Certified Ballast Manufacturers (CBM) certification.

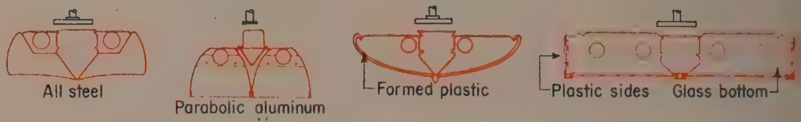
Rigidity of construction is also highly important for suspended type luminaires, both for appearance of the installation after the luminaires have been installed in place, and for ease in cleaning and relamping.

Another important factor in connection with individual suspended luminaires is that the units be installed so that they line up accurately, and so that they will remain in line when cleaned and relamped.

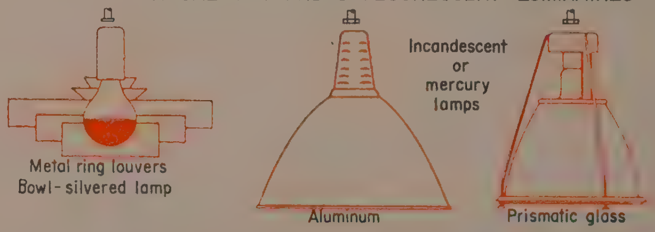
One installation technique which is used for continuous row fluorescent luminaires is to attach the luminaires directly to a continuous rigid metal channel, and to support the entire channel and luminaires by suspension stems connected to the metal channel and supported from outlet boxes above. This method of construction insures that luminaires remain in line after installation, and the mounting height is also better maintained.

In industrial areas, medium and high bay reflectors are often supported on rigid stems. When this technique is used, the stems should be attached to the outlet box by means of a swivel type fitting, or by means of a disconnect type hanger.

Typical Examples of Suspended Luminaires



TYPICAL SUSPENDED FLUORESCENT LUMINAIRES



TYPICAL SUSPENDED INCANDESCENT LUMINAIRES

Architectural Lighting Equipment

Architects have a natural tendency to want to design and use individual lighting treatments on their buildings, rather than to accept standard mass-produced luminaires which are popular designs and used to light a wide variety of buildings and types of occupancies. Also, there is a growing trend to the use of light as elements of architectural design, in which standard design luminaires are not appropriate, or fail to meet the physical and other requirements. Thus architects and lighting engineers design special built-in and architectural lighting treatments which afford the individuality in lighting effects and lighting design which they desire.

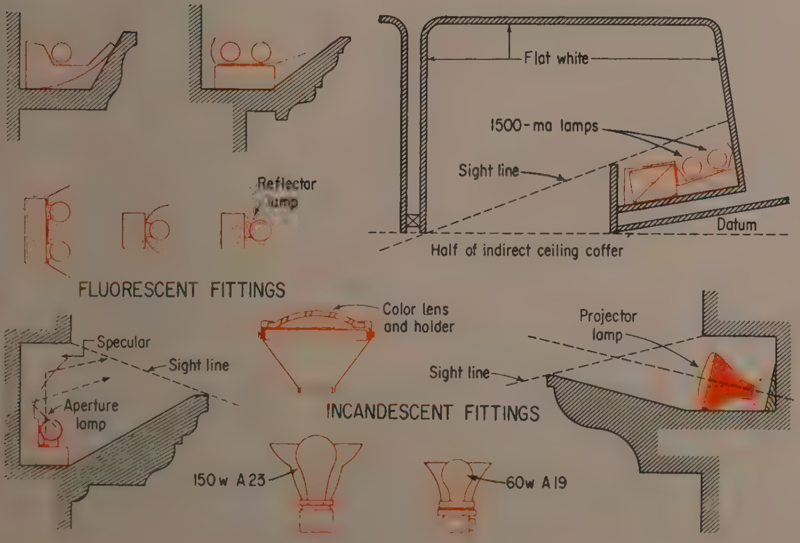
In many instances, special equipment is designed for these architectural lighting treatments, and such equipment may be quite costly. If the final lighting effect is sufficiently dramatic and outstanding, the higher cost may be justified.

One of the developing trends, however, is to use mass-produced lighting devices and lighting equipments, but to assemble and use these devices and materials in such manner as to achieve individual lighting treatments. In such cases, costs are kept at a minimum. An example is that of luminous ceilings, which may be designed as large area low brightness elements, covering only a portion of a ceiling. The lighted element may be in any shape, to conform to the size and shape of the room, and any type of diffusing or shielding materials, or a combination of these materials, may be worked out to be used together. Light sources, lighting strips, and wiring devices can be combined as desired, mixing fluorescent and incandescent lamps, if deemed advisable. With diffusers, plastic and metal louvers, and prismatic plastic or glass panels being mass produced and available in a broad array of patterns, shapes, sizes and colors, a wonderful opportunity exists to create individually styled, lighted elements that will conform aesthetically with the building design and decorative treatments of any area.

Other examples of built-in and architectural lighting elements include luminous wall areas, lighted columns, lighted beams and structural members, round, square or rectangular coffers, coves, cornices, translighted murals, color transparencies, etc. The range of special lighting treatments is limited only by the imagination and ingenuity of the architect and lighting designer.

Of particular interest in this field are the many new light sources and color lighting devices which have been made available in the past several months. The new fluorescent panel lamps, for example, will probably be available ultimately in a range of colors. Being an "area" light source, it will be readily adaptable to decorative wall and ceiling lighting treatments. Also, reflector lamps in color are now available, and some dramatic and highly decorative treatments can now be developed with these light sources, especially when controlled by some of the new and highly flexible dimmer systems.

Typical Architectural Lighting Equipment



Cove lighting, when properly designed, is still an effective method for providing decorative lighting effects. Either the new reflector lamps and color lenses or individual reflector units and standard lamps with color roundels can be used for cove lighting treatments. In either case, lamps or reflectors should be used which provide the correct type of light distribution for evenly lighting the ceiling area, and when color lighting is employed, lamps or reflectors should be selected which do not spill white light out around the base of the lamp or around the color lens fitting. Spill white light can destroy the full effect of the color lighting, and should not be tolerated.

For any architectural lighting treatment which uses fluorescent strip lights, caution should be used to insure that all ballasts used in the strips are of the high power factor type.

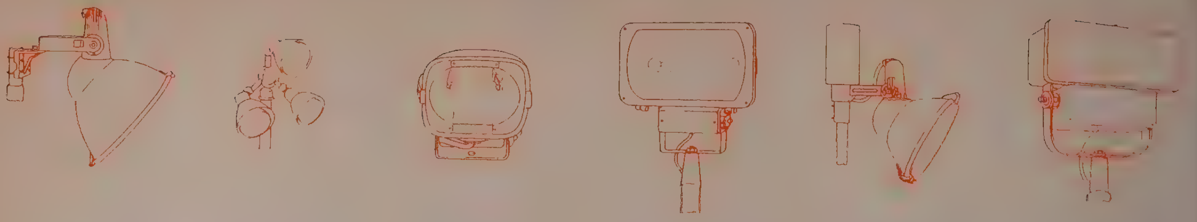
Outdoor Lighting

Electric lighting has made practical the use of light for outdoor activities at night, and in the expanding adaptation of a 24-hour, round-the-clock economy in this nation, there are literally hundreds of outdoor lighting techniques being utilized on thousands of lighting installations.

Outdoor lighting applications may be classified broadly as either of two types—floodlighting, or area lighting. Each type is discussed separately.

Outdoor lighting varies from indoor lighting primarily in that the luminaires, or lighting units, must be made weatherproof when designed for outdoor use. Also, on most outdoor applications there is no overhead "ceiling," or structure to which the luminaires may be attached, as is usually the case indoors. For this reason, it becomes necessary to "project" light from some suitable location where luminaires may be mounted, to the area to be lighted. Thus, "projectors" which project a "flood" of light, or "floodlight projectors" have been designed and made available for outdoor lighting applications.

Typical Outdoor Floodlighting Units


750 - 1500 Watt
150-500 Watt
500 Watt Quartz
1500 Watt Quartz
400 to 1000 Watt
400 to 1000 Watt

INCANDESCENT
MERCURY

There are many needs for light outdoors at night, and most of these needs can be solved by more than one type of lighting equipment, lighting technique, or method of lighting. Some of the more important outdoor lighting requirements are for: 1) streets and highways; 2) bridges, viaducts, tunnels; 3) protection (of buildings, properties); 4) sports areas (baseball, football, tennis, hockey, basketball, golf, race tracks, courts, horseshoe courts, shuffleboard courts, etc.); 5) floodlighting (buildings, monuments, shrubbery, outdoor signboards, railroad yards, docks); 6) area lighting (parking lots, used car lots, gasoline service stations, park grounds, play areas, lawns, etc.).

Consider tennis courts, for example. Tennis courts can be lighted by floodlights installed on poles located at the edge of the playing courts, or by reflector units suspended over the playing courts on aerial suspension wire, or otherwise. In solving the lighting for any outdoor area, it is a good idea to consider two or three different methods of lighting, and then select the one which offers the most advantages at the lowest cost.

Floodlighting Units

Floodlight projectors, or floodlights, as they are commonly called, are of two general types—enclosed weatherproof units, and open type units. They are available in a range of sizes, and types of light distribution, for incandescent and mercury lamps, and a limited range of types for fluorescent lamps.

Since the purpose of a floodlight unit is to project a flood of light, it is necessary to condense this "flood" of light into a beam of some size and shape, such as, for example, a beam 25 degrees wide by 10 degrees high. Where control of the light beam is involved, the "point" source of standard incandescent filament lamps, the approximate "point" source of standard mercury lamps, and the "line" source of the new quartz-iodine incandescent lamps, permit accurate optical control of the light beam. This control is possible through control of the shape and surface of the reflector used in the floodlight unit, and by prismatic control in the lens or cover glass of the unit. Fluorescent lamps are line sources of light, but the "line" varies from 1 to 2 in. in diameter (size of the fluorescent tube), and accurate control is not possible. Where a wide flood of light only is needed, and the floodlights can be located within a few feet of the area to be lighted, fluorescent floodlights may be used successfully. But if the light has to be projected some distance, such as 15 ft or more, more control and efficiency can be obtained from suitable incandescent or mercury floodlights.

Open-type floodlights are usually made in two sizes for incandescent lamps, and one or two sizes for mercury lamps. The smaller size incandescent unit will accommodate either the 300-watt or 500-watt lamp, and the larger size unit will accommodate the 750-, 1000- or 1500-watt lamp. Units are made for base-up burning of the lamp, with the reflector also forming the housing.

Since the light-center-length of a 400-watt mercury lamp is the same as that of a 500-watt PS-35 mogul base incandescent lamp, the smaller sized incandescent floodlights may also be used with 400-watt mercury lamps, and the larger sized incandescent floodlights may be used with 700- or 1000-watt mercury lamps.

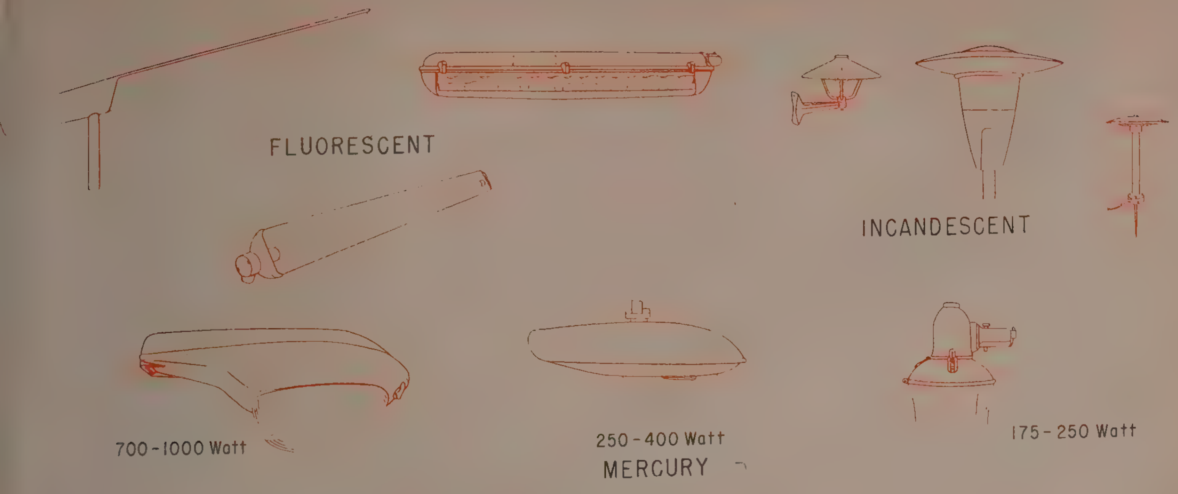
Reflectors for open-type floodlights are made of porcelain-enameled steel, or aluminum with specular, or semi-matte finish. Reflectors should protect the lamp bulbs against rain, sleet or snow, and should be of weatherproof construction, except for the reflector being open.

Enclosed-type floodlights are of two general types—those with reflectors separate from the floodlight housing, and those with reflectors which form the floodlight housing. Each type uses a cover glass or spread-type lens to enclose the reflector or housing, which thereby makes the unit completely weathertight, and protects the lamps from rain and mechanical damage. Enclosed weatherproof floodlights may be operated in any position.

In selecting enclosed-type floodlights, gasket arrangements for making the units weatherproof, and methods used to hinge and hold the cover lenses in place should be checked for adequacy and for ease in opening for cleaning and relamping. Most floodlights are supplied with several different types of mounting bases or mounting arrangements. The proper base should be selected for the type of mounting that will be used. Also, if floodlights require accurate adjustment for uniform brightness of the area being floodlighted (such as a football field), a floodlight should be selected which has an orientation indicator built into the floodlight base and angle adjustment feature of the unit.

Availability of the new quartz-iodine tubular incandescent lamps has resulted in new design floodlights for this new light source. Since the lamp is available in two sizes applicable for floodlighting (500- and 1500-watt), the new quartz-iodine lamp floodlights have also been made available in two sizes. These lamps must be burned in a horizontal position only (within 4 degrees of horizontal), and because of the concentration of their heat in such a limited area of lamp tube, good heat dissipation is a necessity. In selecting these

Typical Outdoor Area Lighting Equipment



nits, these two features are items o be checked.

Area Lighting Equipment

In floodlighting the face of a uilding, or of a monument, it is ecessary to use a floodlight projecor in order to project the light to he area to be lighted. On the other and, there are many types of reas, such as a parking lot, which nay also be lighted by a different ype of luminaire, or lighting unit. These units, which may be floodights, or street lighting types of nits, as well as special "area" ighting units, are now generally referred to as "area" lighting lumiaires, or equipment. Some typical esigns are illustrated in the sketch itled "Typical Outdoor Area Lightng Luminaires." These units are vailable for use with all three ypes of light sources—fluorescent, ncandescent, and mercury.

Included in the "area" lighting quipment are street and highway ighting luminaires. These units are now available for incandescent, nercury, or fluorescent lamps, with pecific and individual designs for ach type of lamp. Street and highvay lighting luminaires have been lassified according to light distrioution characteristics by the Illuninating Engineering Society, and t is recommended that the IES Recommended Practice for Street and Highway Lighting be followed n selecting types of luminaires for hese applications.

In selecting area lighting equipnent, the workmanship and quality of the equipment is of even greater importance than with indoor luminaires. Not only should all outdoor lighting equipment be of weatherproof design and construction, and listed by Underwriters' Laboratories as such, but the materials and finishes should be such that they will not corrode or rust. Latches and fittings on enclosed floodlights, for example, should be of bronze or other rustproof metal.

Reflector and projector lamps of hard glass construction may be used outdoors in weatherproof and watertight adjustable socket housings and fittings. These units provide an economical solution for many floodlighting applications where use of bare lamps is permissible and practical. These units, when equipped with color lenses, make possible the economical lighting of shrubbery, statuary, home garden areas, etc. in dramatic color effects.

A typical application for area lighting is that of off-street parking areas, or of parking areas at shopping centers. While such areas may be lighted by standard type incandescent or mercury lamp floodlights, tower or pole mounted, a recent trend is to the use of fluorescent or mercury lamps in typical street lighting luminaires. Also, special area lighting units, designed specifically for use in lighting parking areas, have been made available. Recommended practice is to provide up to about two footcandles of light for commercial parking lots, and up to five footcandles for shopping centers parking areas. Current practice is to mount luminaires on towers, or on poles, at a suitable height to permit light to be projected to all parts of the area being lighted, and of sufficient mounting height so that direct glare may be avoided. Most manufacturers of outdoor lighting units provide technical data on how to select the proper type of luminaires, and on spacings and mounting heights which will produce uniform lighting and keep glare at a minimum.

Other "area" type of lighting applications include: aircraft service aprons at airport terminal buildings, hanger aprons, excavation and dredging areas at construction projects, storage yards, car loading and unloading areas, freight docks, railroad yards, malls, parks and gardens.

It is not practical to use rule-of-thumb solutions for solving area lighting problems, but it may be helpful to keep some general rules in mind.

1. If use of outdoor lighting is seasonal, or totals less than 1000 burning hours per year, incandescent luminaires will probably be most economical. Otherwise, mercury or fluorescent units in the largest size practical should be considered.

2. Use the minimum number of towers or poles possible which will permit even, uniform illumination.

3. In selecting individual unit light distribution patterns, consider use of the widest beam available, consistent with good utilization.

4. In estimating over-all lighting costs, be sure to include the costs for relamping and cleaning the luminaires.

MOTORS

Selection of a motor in the field becomes necessary when the manufacturer's recommendations are not available or when a particular operation has been redesigned or modified to make the original motor inapplicable.

Choice of a motor for a given application is based upon the functions and characteristics of the load to be driven, the characteristics of the power supply, and the cost. The motor which fulfills the given requirements at minimum horsepower and minimum frame size will usually result in minimum first cost. However, undersizing the motor will reduce its life expectancy.

With load and system criteria fulfilled, there remains the problem of providing the proper enclosure for the motor to suit the ambient operating conditions.

Squirrel-Cage Induction Motors: Motor performance and characteristics are usually demonstrated by means of curves which show the available torque at various speeds. An accompanying curve of this type indicates some of the characteristics of the squirrel-cage induction motor which may be determined.

Full-load torque is an indication of the motor size, since the rated horsepower may be calculated if the full-load torque and speed are known (and vice versa). The permissible overload torque is usually designated by a "service factor" which when multiplied by the nameplate horsepower gives the maximum load the motor can safely carry with all other conditions (voltage, frequency, temperature, ventilation) normal. This service factor, which may be considered as a built-in safety factor, will also permit operation at rated horsepower output but with slight variations in rated voltage or frequency or at a greater-than-standard altitude.

It is evident from the speed-torque curve that operation at a higher-than-rated output will result in a loss of speed. If the load on the motor is increased much beyond the point indicated as permissible for short-time overloads, the condition of breakdown torque is reached, at which point there is an abrupt loss of speed and probable stalling. The pull-up torque is the minimum torque developed during acceleration; the starting torque is that developed at a standstill as acceleration begins. The latter two characteristics are important in determining the motor's adequacy in satisfying the inertia requirements of the load.

An accompanying illustration shows representative speed-torque curves of the most common squirrel-cage induction motor designs, designated in NEMA Standards Pub. MG 1-1959 as Designs A, B, C, D and F. The differences shown by the curves are due primarily to the differences in the rotor resistance and reactance introduced during design. The curves for any specific design also vary according to motor size; output torque values drop as rated hp increases at any given synchronous speed.

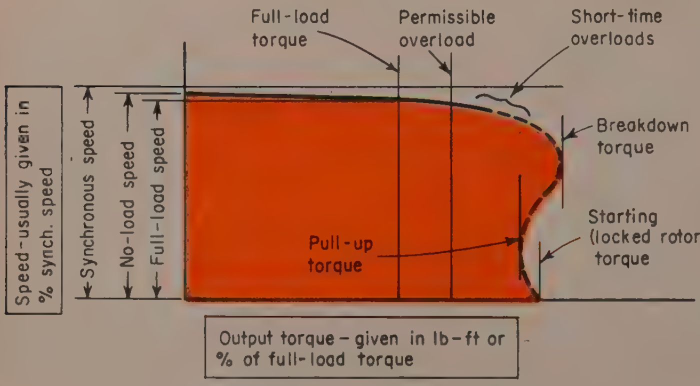
Design B is perhaps industry's "workhorse" for general-purpose across-the-line-starting duty. It has a relatively high starting torque for accelerating high-inertia loads and can handle short-duration overloads to 200% full-load torque or more before reaching the breakdown point. Where the load duty-cycle has a peak in excess of the Design B breakdown torque, a Design A motor may be used. This type has the same starting torque as the Design B motor but develops a higher breakdown torque.

The Design C motor is characterized by a low starting current and high starting torque. It is suitable for loads requiring a high starting torque and rather rapid acceleration, such as conveyors and loaded line shafts. For extremely heavy starting conditions, the Design D motor is available. It is well suited for such high-inertia loads as punch presses, although its running efficiency is low.

The Design F motor is the least used of the five types. It is manufactured in sizes usually 30 hp and greater for use where starting current must be limited. Since its breakdown torque is also low, a larger size will normally have to be supplied to handle the same load as a standard motor. Accordingly, it is often more economical to supply a Design A, B or C motor with reduced-current starting rather than a Design F motor across the line.

It is likely that more than one type motor will perform satisfactorily in almost any given situation with some sacrifice in operating economy or at higher initial cost. The best motor for the job can be selected only after load tests are made under actual operating conditions.

Polyphase Induction Motor Characteristics

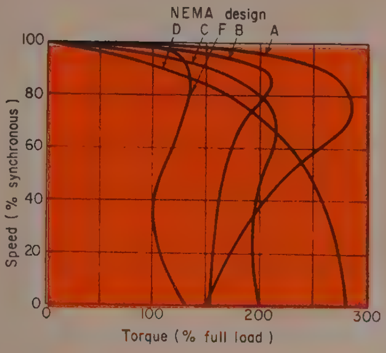


(Dotted portion of curve represents initial acceleration.)

Wound-Rotor Motors: The wound-rotor induction or slip-ring motor is provided with a means for varying the rotor resistance externally. Adjusting the rotor resistance does not change the maximum torque developed; however, it varies the speed at which maximum torque is achieved. Hence the external resistance may be used for limited speed control on certain types of driven loads. The external resistance is also used to limit current during starting. Typical applications of the slip-ring motor include reciprocating compressors, crushers, and blowers requiring high starting torque.

Synchronous Motors: Widespread application of the synchronous motor is due principally to two characteristics: the machine operates at a constant synchronous speed at all expected loads; and its unusually high power factor leads to economical operation and its use for system power-factor correction. Disadvantages include higher initial costs, higher maintenance costs, and the necessity for providing a source of dc excitation. Typical applications are for generators, compressors, and centrifugal pumps where constant speed is essential. A synchronous motor corrects for lagging power factor by drawing from the line current which leads the voltage, thus neutralizing a portion of the lagging current drawn by the remainder of the load. The capacity of the motor must be increased over and above that required to drive its load by the amount of excess current it draws.

Speed-Torque Curves, Induction Motors



Direct-Current Motors. The high initial cost, high maintenance cost, and rather bulky control equipment required limit the use of dc motors. However, the relative ease and extent of speed control possible makes the dc motor useful for both constant- and variable-torque loads requiring speed adjustment. Shunt, series, and compound windings are available.

Consideration must be given also to the availability of a suitable dc source of sufficient capacity.

Universal Motors: Essentially a series motor, the universal motor operates on both dc and ac circuits. It is usually of fractional-horsepower size and is used primarily for portable appliances such as vacuum cleaners and food mixers.

Definite-Purpose Motors: There are motor applications which require features not available in the general-purpose category. A standard motor may be modified for the purpose; but where the demand for the motor is sufficient, separate standard specifications are set up. NEMA provides standards for several motors it defines as definite-purpose, such as oil burner, sump pump, gasoline-dispensing pump, coolant pump, submersible, home laundry, hermetic, and fan and blower. In general, motors so designated are used only for the stipulated purpose, since mechanical features such as type of enclosure or provisions for mounting would have to be modified.

Special-Purpose Motors: Where required design characteristics are not met by standard motors, special motors must be designed. The special design may be either mechanical or electrical or both. Mechanically special features include the enclosure, mounting, size, bearing construction, insulation, and method of cooling. Motors requiring such mechanical modifications include pancake motors (for use where space is at a premium); shell- or can-type motors (furnished without housing for built-in applications); vertical hollow-shaft motors (for pumping applications); self-cleaning textile motors (which dissipate airborne dust and lint); and sanitary motors (designed to prevent dirt accumulation and permit washing down).

Examples of electrically special motors are those designed for special duty cycles such as encountered with hoists and cranes; or slow-accelerating motors for extractor duty employing centrifugal force.

MOTOR CONTROL

The principal functions of a motor controller are to start and stop the motor and protect it against overloads or other abnormal operation, with proper attention to the safety of the operator. Controllers may be designed to connect the motor directly to the line (across-the-line starters) or to accelerate the motor at a reduced voltage before direct connection to the line (reduced-voltage starters). Choosing one or the other depends upon the characteristics of the motor, the distribution system, and the starter itself.

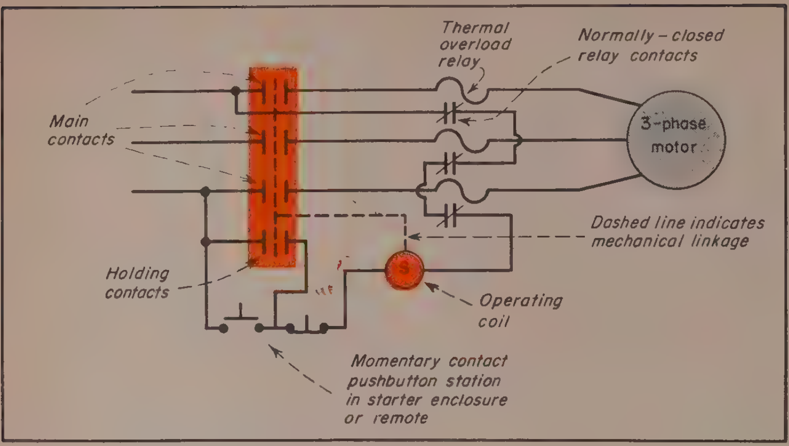
Across-the-Line Starters

Full-voltage starting requirements may be handled by a manual starter, a magnetic starter, or a combination starter, each of which normally incorporates some type of device for overload protection.

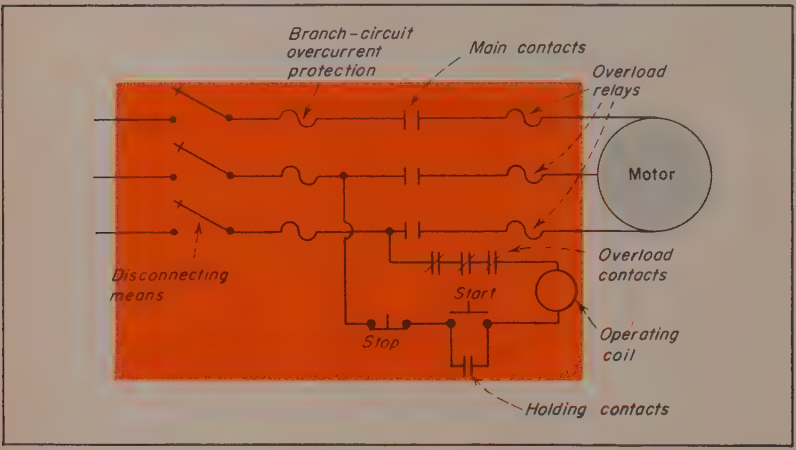
The manual starter consists of a pushbutton-operated switch plus overload relays in a suitable enclosure. It is normally mounted close to the motor it controls and merely acts to connect the line voltage to the motor.

The magnetic starter includes an

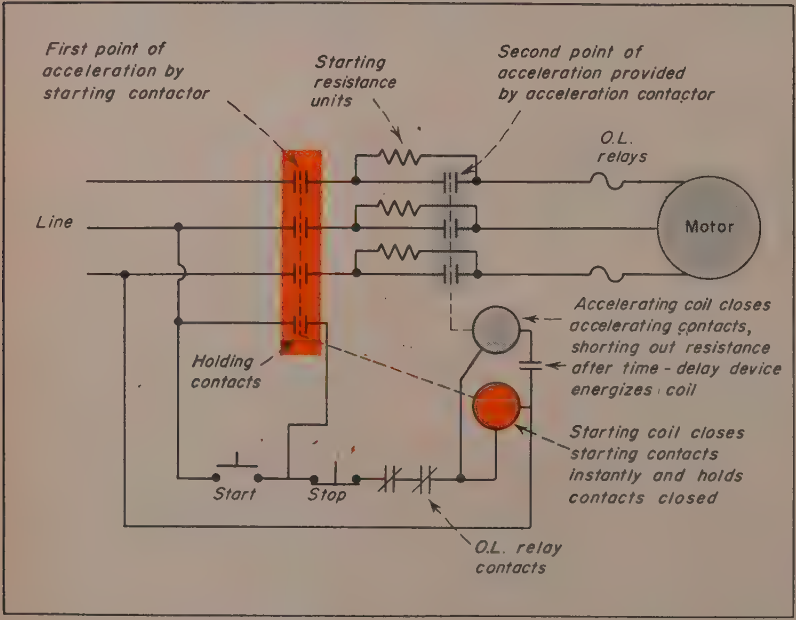
Magnetic Across-the-Line Starter


Thermal overload relay
Normally-closed relay contacts
Main contacts
3-phase motor
Dashed line indicates mechanical linkage
Holding contacts
Operating coil
Momentary contact pushbutton station in starter enclosure or remote

Combination Starter with Fused-Switch Disconnect



Reduced-Voltage Resistance Starter


First point of acceleration by starting contactor
Starting resistance units
Second point of acceleration provided by acceleration contactor
O.L. relays
Line
Motor
Accelerating coil closes accelerating contacts, shorting out resistance after time-delay device energizes coil
Holding contacts
Starting coil closes starting contacts instantly and holds contacts closed
Start
Stop
O.L. relay contacts

electromagnet to replace the pushbuttons. The control circuit to the electromagnet uses a switch, thermostat, or other pilot device to energize the magnet coil and start the motor. Starting may thus be automatic and may be initiated from any number of points close to or remote from the motor.

The combination starter incorporates in addition a disconnect switch, a disconnect switch plus branch-circuit protection, or circuit breakers which double as disconnect and branch-circuit protection. Use of this equipment reduces installation labor costs, although initial equipment costs will be greater than with a separate disconnect.

Reduced-Voltage Starting

Where starting a motor at full voltage may have an objectionable effect on the distribution system, or where the driven load may be damaged by sudden application of full torque, a reduced-voltage starter may be used. This involves the connection of the motor to the line through a resistive or reactive element for a short period of time until the motor builds up speed. Both the starting current and the torque are reduced; therefore, reduced-voltage starting should not be used where a load requires full starting torque.

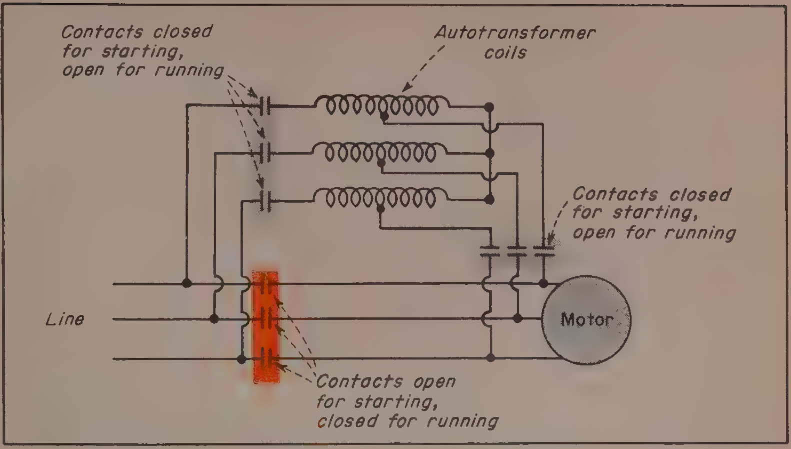
Use of resistance in series with each phase during starting results in extra power losses; however, where motor starting is infrequent, such as on pumps, compressors, or blowers, this loss may not be objectionable. The resistance may be shorted out in one step or in several steps as the motor comes up to speed.

The autotransformer starter connects the motor to the line through an autotransformer as it accelerates and then transfers it to full voltage. Taps on the transformer winding permit selection of a range of starting torques; greater efficiency is realized since the only power losses are those in the transformer. This type of starter permits lower starting currents than the resistor type.

A third type is the reactor starter, similar to the resistance type except that a reactor is in series with each phase, providing taps to obtain different voltages. Its efficiency is higher than that of the resistance starter, but it reduces the circuit power factor.

Dual-voltage motors or specially wound part-winding motors may be started using part-winding starters. These consist of two half-size starters in a common enclosure, each controlling one of the two motor windings. At start, one starter accelerates the motor. After a preset time determined by a time-delay relay, the second starter closes, placing the two stator windings in parallel for full-speed operation. This method is the least expensive of the reduced-voltage starters, but the starting torque is only 50% of full-voltage starting torque.

Autotransformer Starter


Contacts closed for starting, open for running
Autotransformer coils
Contacts closed for starting, open for running
Line
Motor
Contacts open for starting, closed for running

Selection Criteria

From the above, it should be evident that the selection of a motor and its controller should be made concurrently, taking into consideration the effect on the load, the effect on the distribution system, and the cost. If the load can take the impact of full starting torque and if the transient voltages and currents incurred on starting are not objectionable, an across-the-line starter should be considered. Except for the part-winding starter, the cost of other types of reduced-voltage starters will be several times that of the across-the-line starter. Line-voltage starters are generally available for motors rated up to approximately 75 hp; reduced-voltage starters are not normally used for motors below 5 hp.

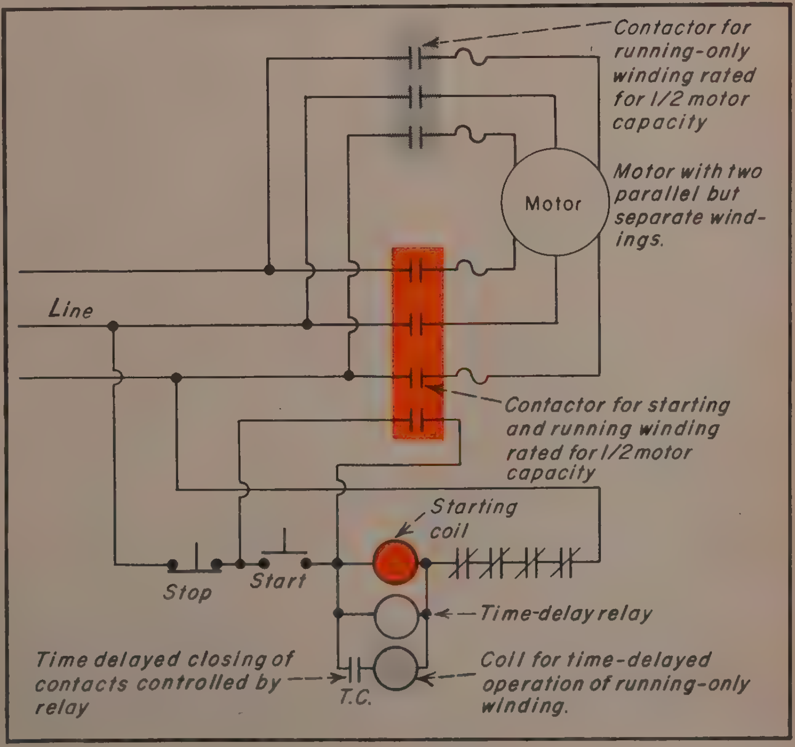
Selection of overload relays for use with a particular starter and motor is more or less automatic; each manufacturer furnishes relays and selection tables for their proper use, depending on full-load motor current. Across-the-line starters usually employ thermal relays in series with the line using a fusible alloy which melts upon a sustained overload, opening the circuit. Magnetic starters normally use magnetic-type overcurrent relays with their contacts in series with the control circuit. Excess line current generates sufficient heat by transformer action to melt solder used in the contacts. Resulting mechanical action opens the relay contacts, breaking the control circuit and dropping out the line contactors.

Overcurrent protection is normally provided in all ungrounded line conductors feeding the motor, except that it has been standard practice to use relays in only two of the three phases feeding a 3-phase motor. However, since many motor burnouts are attributed to this lack of protection in the third phase, the 2 to 3% additional cost of the third relay represents good insurance against loss of the motor from this cause. Starters today have provision for the inclusion of three relays.

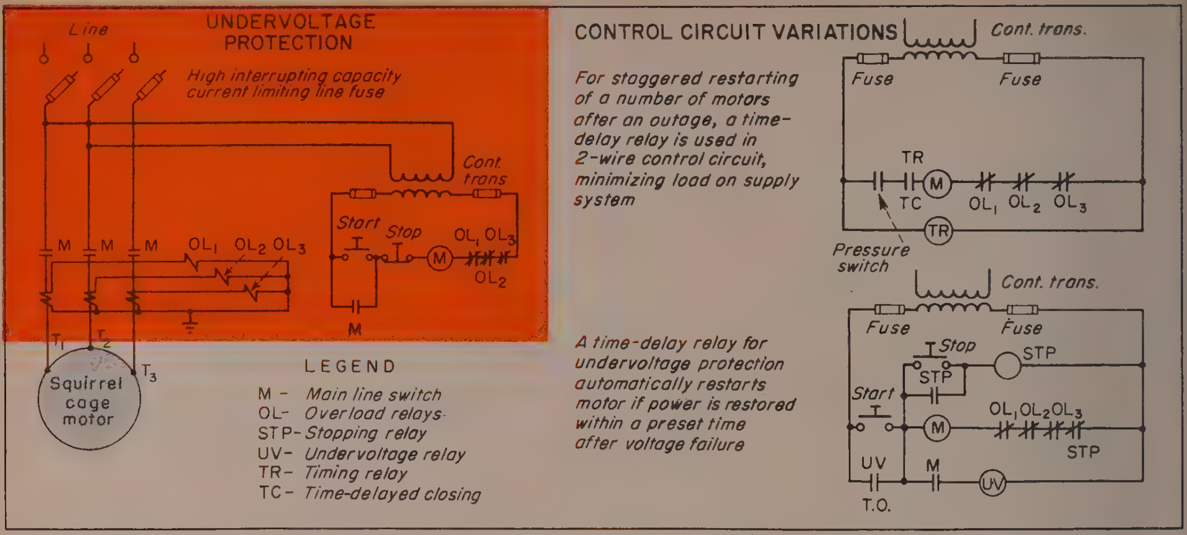
Magnetic starters also provide protection against reduction or loss of line voltage, since the operating coil in the control circuit drops out its contacts when the voltage is too low to sustain its magnetic field.

The wiring used in the control circuit will determine whether the motor need be restarted manually when power is restored. If unexpected automatic restarting of the motor can result in injury to personnel or damage to driven equipment, or if restoration of power would cause several large motors to be started simultaneously, complete overcurrent protection must be incorporated which will make it necessary to restart such motors manually.

Two-Step Part-Winding Starter


Contactor for running-only winding rated for 1/2 motor capacity
Motor with two parallel but separate windings
Motor
Line
Contactor for starting and running winding rated for 1/2 motor capacity
Starting coil
Stop
Start
Time-delay relay
Time delayed closing of contacts controlled by relay
T.C.
Coil for time-delayed operation of running-only winding

High-Voltage Starter for Squirrel-Cage Motor


Line
UNDERVOLTAGE PROTECTION
High interrupting capacity current limiting line fuse
Cont. trans
Start
Stop
M
OL₁ OL₂ OL₃
T₁ T₂ T₃
Squirrel cage motor
LEGEND
M - Main line switch
OL- Overload relays
STP- Stopping relay
UV- Undervoltage relay
TR- Timing relay
TC- Time-delayed closing
CONTROL CIRCUIT VARIATIONS
Cont. trans.
Fuse
For staggered restarting of a number of motors after an outage, a time-delay relay is used in 2-wire control circuit, minimizing load on supply system
TR
TC
Pressure switch
A time-delay relay for undervoltage protection automatically restarts motor if power is restored within a preset time after voltage failure
STP
UV
T.O.

CONTROLLERS suitable for motors in the 2.3- to 5-kv range are now available in a greater selection of sizes with integrated components and accessories specifically designed for the application to better serve the increased usage of higher-voltage motors for pumps, compressors, refrigeration equipment, etc. New developments in motor insulations have made such voltages practical, with attendant benefits and economies due to the reduced current-handling capacity required of feeders and auxiliary equipment. Heretofore, compromises have had to be made both in operating efficiency and in economy of application because of the necessity of modifying existing components not designed for the lower voltages. When primary voltage is available, its use for motor supply can greatly reduce required step-down transformer capacity.

ELECTRIC HEATING

If it were necessary to describe with a single word a principle to guide the selection of heating equipment, that word would be *dispersion.* If all the surroundings to which the body is exposed, including the air, were at a uniform temperature in the 70° to 75°F range under proper conditions of relative humidity, optimum comfort would be achieved for most people. The body would thus radiate its generated heat at a uniform and comfortable rate in all directions.

By combining electric heat with room-by-room control and effective thermal insulating techniques, we can closely approximate optimum conditions. Underlying all choice of systems and equipment should be the attempt to promote uniform heating and avoid local effects which tend to induce directional discomfort. Walls, floors and ceilings adjoining other heated spaces present little problem; thorough insulating of walls, floors and ceilings exposed to unheated spaces or the weather can bring the inside surface temperatures very close to that of the inside air. It remains then to introduce the heat into the space in such a manner as to reduce the discomfort effect of the remaining cooler surfaces (doors and windows), to neutralize drafts caused by the infiltration of cold air into the heated space, and to keep these conditions constant through the use of appropriate control devices.

Lacking a totally dispersed heating source, equipment should be chosen which may be utilized to best accomplish the above objective. It is significant that the two electric heating methods comprising the greatest percentage of the more than a million installations already in use are ceiling cable and wall baseboard. The former accomplishes uniform downward radiation over the entire heated space; the latter permits uniform distribution of heat along the entire length of exposed walls.

Actually, many variables and restrictions dictate that a compromise is usually necessary. These include cost and availability of equipment, and the nature and construction of the building to be heated. The extent and type of occupancy will dictate the amount of ventilating or exhaust air required; building materials used and temperatures of exposed surfaces may indicate that more than one type of heater is best suitable. Familiarity with all available types will permit the exercise of judgment in providing maximum comfort.

Heating Elements

Resistance heating elements operate on the basic principle that heat is generated as a result of friction encountered by electric current as it passes through a conductor. The essential requirements therefore include a conductor and two terminals through which the current from the supply circuit may enter and leave the element. The rate at which heat will be generated depends upon the supply voltage and the resistance of the conductor. The resistance in turn is determined by the nature of the conductor and the length of the current path through it. The conductor configuration may be linear or coiled, bare or encased—similar or identical to elements used in the familiar tubular, strip, cartridge, and immersion heaters found in industrial or process applications.

Bare or enameled elements may be arranged on ceramic cones or suspended in the air stream by suitable insulating supports. Flat strip heaters employ a metal jacket which completely envelops the conductor over an insulating filler; most other types use a resistance wire embedded in refractory material and enclosed in a tubular iron or alloy sheath. The resulting assembly may be bent into any configuration desired for mounting in free air, for immersion in water, or cast as an integral part of metal elements designed to provide efficient additional radiating surface.

Glass panels, long used as a radiant emitter in electric heaters, may have a metallic conductor applied in a serpentine-like arrangement on the rear face; or a continuous conductive film may be used. In the latter case, pressure strips are fixed to the coating at opposite edges through which the current is introduced to the film. In both cases, heat is transferred by conduction to the glass, from which it is radiated into the occupied space. Large-area metal panels are also being used as a radiating surface in some heaters with the conductive element applied to the rear face in a manner resembling that used in electronic printed-circuit applications.

Heating elements are designed for operation at a specific circuit voltage—usually 120, 208, or 240 volts—and it is important that the rated voltage be actually achieved. Overvoltage will result in decreased element life; undervoltage will produce less than rated heat output.

Heat Transfer

As stated above, electricity is converted to heat at 100% efficiency in a resistance device. There remains, however, the problem of transferring the resulting heat from the unit to the occupant who is to benefit. Although some conduction of heat is involved, most resistance heaters are designed to dissipate the heat through radiation or convection. Radiation accomplishes heat transfer from the heated surface to a heat-absorbing surface without heating the intervening air, as the sun heats the earth. Convection involves the passage of air across the heated surface; heat is transferred to the air and carried by the air. Convection may be *natural*, depending upon existing air currents and the physical tendency of warm air to rise, or it may be *forced*, utilizing a fan or blower to accelerate the movement of air past the heating element.

Heaters are normally designed as either predominantly radiant or convection heaters, although some radiation and some convection is always present in each type of design. The exact percentage of each is usually difficult and costly to ascertain precisely and usually is not of paramount importance. In general, the rate at which any heater will emit radiant energy depends upon the temperature, area, and finish of the radiating surface.

The choice of heating element also determines the wavelength at which most of the energy will be radiated. Most comfort heaters emit radiation in the far infrared portion of the spectrum, and the radiation is not visible. Such emitters as the quartz lamp, however, radiate at near infrared wavelengths, that portion of the spectrum closest to visible light. Hence a great portion of the radiation is visible, and such heaters are often used to fulfill both heating and lighting requirements.

Selection Criteria

There are several general factors which influence the selection of one heater over another similar heater irrespective of the operating principle. These include size, appearance, safety, operating temperature, ease of installation, expected life, availability, and manufacturers' reputations.

Space available will dictate maximum heater dimensions which can be accommodated. A contributing factor could be the desire to either emphasize or minimize the existence of the heater from esthetic considerations.

The appearance of the unit and the extent to which the appearance may be modified are important. In most cases, the heaters become a permanent, visible part of the building's occupied areas. In the residence, the housewife in particular must be satisfied; the heaters will become a subject of conversation and an object of inspection by all visitors. Accordingly, a simple design is indicated, unmarred by clutter or unnecessary trim. The original finish should be complementary to a wide range of interior decorating materials and colors, or repainting should be possible to match decorating changes.

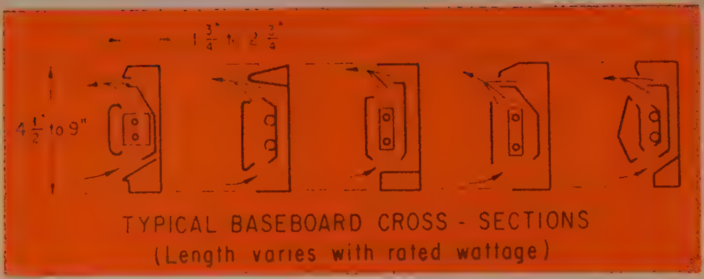
Safety is assured by units bearing the label of the Underwriters' Laboratories and conforming to its *Standards for Safety: Electric Space-Heating Equipment* (*UL-*573). In general, construction requirements afford protection from physical damage; maximum surface and element operating temperatures are specified; thermal cutout protection is required to avoid a dangerous buildup of heat through overload, obstruction, or fan failure; and bare current-carrying elements must be protected.

Heaters should be expected to last indefinitely. Normal life may be expected of motors, switches and other moving assemblies. Most units carry a generous warranty to cover possible defects in manufacture.

Heater Types

Baseboard Heaters. These are today's "best-sellers" in the residential market and are used extensively in commercial and institutional buildings. They are designed to occupy a minimum of space along the junction of the floor and the outside wall, leaving more room for furniture arrangement. They may be installed in any continuous length; inside and outside corner fittings are available which match the baseboard design and permit it to turn corners and follow the wall configuration if necessary.

Individual baseboard heater sections are normally fastened together end-to-end and wired in parallel using knockouts and terminals provided, although at least one is designed so that successive sections may be plugged together. Some incorporate space at the bot-


1 3/4" to 2 3/4"
4 1/2" to 9"
TYPICAL BASEBOARD CROSS - SECTIONS
(Length varies with rated wattage)

BASEBOARD HEATERS are available in various sizes and shapes, capacity per ft of length, and type of element. In general, design permits cooler air to enter at bottom, travel up past element and through various baffle arrangements by convection, and out into room at top.

tom which is approved as a raceway. Most units are designed for surface mounting on finished wall. Recessing may interfere with the free flow of air through the unit or cause discoloration of the wall above the baseboard, although partial recessing may be anticipated in the design of some units. The sheet metal configuration is designed to deflect the heated air into the room and away from the wall immediately above the baseboard to minimize the impingement of dirt particles on the wall which are carried upward from the floor by the heated air.

Initial cost can usually be minimized by the selection of a unit having the largest capacity in watts per ft of length; however this represents the least desirable installation from a comfort standpoint. Also, concentrating more heat in less area results in higher temperatures. This can increase wall or window drape discoloration because of the movement of dirt particles. There is also some evidence of chemical breakdown of lint from certain synthetic carpeting when exposed to high temperatures, with a resultant increase in dirt nuisance. Baseboard units may be obtained in densities anywhere from 100 to 400 watts per ft of length. The lower ratings, in the neighborhood of 200 watts per ft or lower, are to be preferred for quality installations. Typical depth and height variations are indicated on the accompanying sketch.

Since air movement is required to transfer the heat from the element to the room interior, these baseboards are essentially convection heaters. There is also a small percentage of radiation involved from the heated portions of the metal enclosure facing the room.

Baseboard heaters should not be specified unless they contain continuous thermal elements or individual thermal cutouts spaced throughout the entire heater length to shut off the current should excessive local temperatures be created by some obstruction accidentally placed against the heater to cut off air flow. Element temperatures may vary considerably even within the acceptable limits due to the design or type of element employed. Here again, the lower temperatures are to be preferred.

Some baseboard units depart from the general construction and operating principle depicted in the sketch. At least one type incorporates a blower to draw air into the heater and direct it into the room under pressure. Heaters which employ glass elements have a higher radiation component, although a substantial portion of the heat transfer is by natural convection. The flat glass radiating surface may have the heat transferred to it by conduction from a metallic circuit "printed" or adhered to its rear face, or from a continuous conductive film applied to the rear surface and energized through metallic strips clamped to each end.

Resistance baseboard is also available for use with a system of ductwork and a central blower to incorporate continuous low-velocity circulation of tempered air.

Electric hydronic baseboard heaters are in use employing water to effect heat transfer. One type resembles the conventional baseboard in appearance, but each section has its own self-contained water supply. The water circulates in a closed loop of copper tubing containing an immersion heater in the lower section and external fins to distribute the heat on the upper section. A short extension of the tubing at one end serves as an expansion chamber; an electrical limit control protects against overheating. No plumbing connections are required. Another type uses cast-iron radiator sections which may be bolted together to provide any length of radiation. All units of this system are interconnected by ¼-in. copper tubing to a central expansion tank and relief valve; however, water circulates only within each individual heater and not between heaters. Each section has its own heating element immersed in the water. Both of these systems utilize the heat-storage capacity of water to extend the period of heat transfer between thermostat cycles.

Complete hydronic systems are also available using electricity as a source of energy in which hot water circulates continuously through finned baseboard radiators. Magnetically operated valves control the circulation over one or more zones in accordance with air temperatures. Heating elements may be energized only during off-peak hours and the hot water accumulated in storage tanks, to be used as needed. Such a system may be particularly advantageous where special low off-peak electricity rates are offered by the utility.

Heating Cable. Resistance cable embedded in the ceiling produces in most cases a very satisfactory heat. It is completely invisible, takes up no room space, does not interfere with furniture arrangement, and provides maximum dispersion of heat.

Thermoplastic-insulated copper-alloy wire is used for ceiling applications, usually designed to produce about 2¾ watts of heat per ft of length. It is manufactured in many lengths to provide a wide variety of wattages at rated voltage to satisfy almost any heat-loss situation. Cable lengths are provided with non-heating leads at each end which are brought down into the wall for connection to the branch circuit and thermostat. These non-heating leads have a much lower resistance than the remainder of the cable length so that they do not heat up when carrying rated current. In the past, these leads required some protection, such as loom, in their passage through the wall. Ceiling cable is now available with non-heating leads approved for installation without such protection. In any case, the cables are meant to be used as supplied and must not be modified. It is installed by stapling to a firm flat surface, such as gypsum lath, at a previously determined spacing using a stapling gun designed for the purpose. Installation should be made as recommended by the cable manufacturer in conformance with special provisions outlined in Article 422 of the NEC. After the cable is in place, the finish plaster coat or gypsum board is applied.

Ceiling cable may be unsatisfactory where there are large glass areas and may have to be supplemented by some convection or forced-air heaters to effectively counteract downdrafts from the cold glass surfaces. Also, ceiling cable is essentially restricted to residential occupancies. Institutional and commercial buildings normally have cluttered ceilings (pipes, lighting units, etc.), require the use of insulating acoustical tile, and have rather high ventilation requirements with which other electric heating equipment is more readily adaptable.

Cable embedded in concrete floors is also effective, although the predominance of frame floors in residences has restricted its use in this country. When used in concrete floors designed for high thermal storage capacity, floor heating can be used to take advantage of low off-peak electricity rates. In general, because of the time and energy required to bring the floor to its design temperature, floor heating is most applicable where the space to be heated is to be more or less continuously occupied. It is also effective where it is especially important that the floor be warm, such as in a school kindergarten, where the children spend a great deal of time on the floor. In floor applications, cable is fastened to wooden sleepers in the first concrete pour, using spacing devices, after which the final concrete pour is made.

If either ceiling or floor cable is used, close coordination with the building contractor is necessary to avoid cable damage.

Ceiling Heaters. Units designed for installation in or on ceilings have the advantage of requiring no floor or wall space. Ceiling heaters have been used extensively for residential bathroom applications, where wall space is usually at a premium. The convenience of instant heat, the ease of control, and the savings in ductwork, especially in such multiple occupancies as apartment buildings, have resulted in such heaters being specified for use in the bath even where the remainder of the building is heated by conventional fuels.

Available units include those providing heating only, heating plus lighting, or heating, lighting, and ventilation. Almost all types of heating elements are used, including glass panels and infrared lamps. Heating capacities are usually restricted to 1500 watts or less, at 120, 208, or 240 volts. Where lights or exhaust blower are provided, they are wired on a separate circuit and may be operated independently of the heating element.

Radiant metal or glass ceiling panels are also being made for applications other than baths. Measuring 2 by 4 or 2 by 5 ft and rated 500 or 700 watts, the units are adaptable to home and office use. They may be accommodated on acoustically tiled ceilings by omitting eight or ten 12-in.-sq tiles. Recessed units are practically flush with the ceiling; surface units project only 1 in. beneath the surface.

Wall Heaters. As the name implies, wall heaters are designed for surface or recessed mounting in walls. The element may be any of the types previously described and may be designed predominantly as radiant or convection (natural or forced) heaters. They may be used throughout an installation or to supplement cable or baseboard systems where necessary or desirable. Their size ranges anywhere from about 8 by 10 in. upward to about 2 by 2 ft. Cabinet convectors, incorporating ventilators and intended for school classrooms and similar installations, may be 3 by 6 ft and larger. Extension into the room varies from 2 to 14 in.; heaters may be either surface or recessed type.

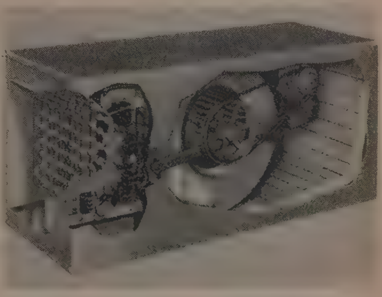
Units are usually placed beneath windows. However, since this type of heater necessarily concentrates its heat output from a small-area source, a better job will result from the use of several smaller-capacity heaters rather than one large unit, requiring locations other than below windows.

Like baseboard, wall heaters may incorporate a built-in thermostat or may be operated by a wall-mounted thermostat. An additional feature of some units is a switch to operate the fan during the nonheating season for ventilation purposes without energizing the heater. Heaters should incorporate a thermal cutout to guard against excessive temperatures. Such devices also serve to disconnect the element of forced-air heaters should the fan fail or be accidentally disconnected.

Ratings of wall heaters range from 500 to 6000 watts; cabinet ventilators may be obtained from 2 to 18 kw with air delivery capacities up to 1250 cfm. The larger capacities, for commercial or institutional applications, are available for 3-phase operation at 208, 240, and 277 volts or higher.

Unit Heaters. For complete space heating of industrial areas or such large spaces as auditoriums, gymnasiums, cafeterias, courtrooms and airplane hangars, large-capacity heaters are necessary. Unit heaters incorporating fans or blowers are often used for such applications. These are completely enclosed forced-air units designed to be mounted within the heated space by means of brackets attached to wall or ceiling steelwork, or they may be supported on a suitable floor pedestal. Capacities range from ½ to 132 kw, with air-handling capabilities to 15,000 cfm, for supply voltages ranging from 120 volts single-phase to 575 volts 3-phase. Standard motor starters, relays, and contactors are used in addition to necessary thermostats to control heater operation. Explosion-proof models up to 6 kw are also available for Class 1, Groups C and D applications.

Central Furnaces. Individual isolated applications of the central electric furnace to residential heating may be traced back through many years; however, the equip-



CENTRAL ELECTRIC FURNACE of compact design may be installed horizontally or vertically in closet, utility room or basement. From left to right are heating elements, control panel, blower, blower motor, and filter.

ment being sold today is of recent origin.

The central furnace is actually a compromise between individual room electric heaters and no electric heat at all. The advantages of individual room control, the 100% efficiency resulting from transformation of electrical energy into heat in the precise space it is to be utilized, and the smaller cost of installation and maintenance are sacrificed. In addition, past experience with central furnaces has indicated an increased operating cost over room heaters of approximately 20%. This undoubtedly has been due to heat loss from improperly insulated ducts passing through unheated spaces or through rooms already at design temperature.

With adequate duct insulation and new modulating temperature controls combined with multistage element operation, it can be expected that the operating cost differential will be narrowed. In addition, central furnaces may be installed with heating elements in the discharge registers rather than in the furnace itself, with individual room thermostats. This amounts to individual room heaters, with the added advantage of continuous air circulation; but it involves the extra cost of the central unit and its associated ductwork.

The central furnace simplifies the summer air-cooling problem, since the same ductwork may be used. Here again a compromise is indicated. The ideal location for forced-air heating outlets is near the floor, while the most effective location for cooling outlets is high on the wall or in the ceiling. It follows that independent room heaters plus a central air conditioner with ideally located outlets would be more conducive to comfort than a central heater-air conditioner with dual-purpose outlets, even with the heating elements installed in the outlets, at approximately equivalent first cost.

This comparison requires some modification when an existing structure is to be converted from fuel forced-air to electric heating, if the existing ductwork can be used, since the extra cost of the ducts and their installation is not involved.

Additional advantages in favor of the central furnace over the nonducted system include the relative ease of introducing tempered fresh air and its beneficial effect on air circulation and humidity control, and the ease by which air cleaning may be introduced. Packaged electronic air cleaners may be inserted, with slight modification of the ductwork, which are many times as efficient as the simple filters long used with forced-air systems.

Central furnaces with multistage control reduce the previous objection to the rather large sudden load introduced on the utility's lines and possible extra costs due to demand charges when single thermostats were used, even though the favorable diversity of individual room heaters is not achieved.

Through appropriate arrangements of the air conditioner and heating elements in conjunction with a humidistat, the air conditioner can be used during the heating months to accomplish dehumidification through the process of reheat should the introduction of outside air be insufficient to reduce high indoor relative humidities. Conditions of low humidity, although rare with electric heating systems, can also be rectified through the ready addition of humidifying equipment.

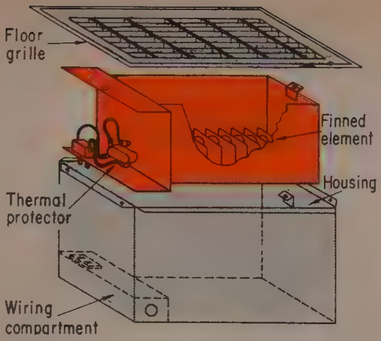
Heat Pumps. Working on a "reverse-cycle" principle similar to that used in the familiar household refrigerator, heat pumps hold two important advantages over resistance heaters. They perform the dual function of heating and cooling with the same equipment, and, under favorable conditions, can operate at lower costs. By extracting available heat from the outside air, from water, or from the ground and transferring it to the inside air, more energy can be delivered to the heated space than is necessary to operate the compressor motor, blower motor, and other electrical equipment involved. The least expensive equipment from the standpoint of initial cost will usually be the air-to-air type. It is also the most commonly used, since air is always readily available.

Available equipment varies from small packaged room units and residential central units to large custom equipment for commercial use. Practically any heat-loss requirement may be fulfilled. However, the amount of heat available to the heat pump is dependent upon the temperature of the air, water or soil from which it is to be extracted. Accordingly, it can be expected that the heat pump will operate most efficiently in the more temperate areas of the country, although many successful installations are in operation in rather severe climates. In general, where outdoor temperatures are 30°F or higher, the single-stage heat pump usually produces a satisfactory installation. Where temperatures are lower, the heat pump may be fitted with auxiliary resistance heaters so that when the heat required exceeds that available, the resistance heaters are automatically energized to supply the deficiency. The operating range for use without resistance heaters may be extended to temperatures below zero by multistage or compound compression.

Initial and operating costs are lowest when a heat pump is selected so that it operates at 100% capacity without the need for auxiliary resistance heaters. Full utilization of provided capacity usually requires that the cooling load be greater than the heating load. Buildings with high internal heat gains will thus be better suited for heat-pump application, since they may offset a considerable portion of the heat loss and permit operation without auxiliary resistance heat at a lower temperature.

DUCT HEATER for heat-pump auxiliary resistance heat or forced-air applications contains coiled-wire element exposed directly to air stream. Control panel at right, which is outside the duct when mounted, includes a temperature limit control, relays, thermostat transformer, and terminal strips. Several units may be banked in series or parallel to satisfy capacity requirements.

Infrared Heaters. High-temperature radiant heating is used extensively where heating the air would be impractical or costly. Typical installations include specific work stations in uninsulated industrial buildings; partially sheltered outdoor areas such as loading docks or sports grandstands; or buildings with large volumes and high ceilings, such as gymnasiums.



FLOOR INSERT HEATERS are used in residences or commercial occupancies where wall space is restricted or unavailable, such as where large windows and sliding glass doors are used. The metal housing is recessed between floor joists or in a framed floor pocket provided during construction. In concrete slabs, the enclosure is fixed in place and wired before the concrete is poured. Units are typically approximately 8 in. deep, 5 to 8 in. wide, and from 1 to 6 ft in length, depending upon the heater's capacity. Individual heaters are rated from 350 to 3000 watts. In some units, the element assembly may be lifted to permit vacuuming of the housing. As shown in the sketch, the element plugs into a receptacle in the wiring compartment.

Major types of infrared heat sources include the heat lamp, the quartz tube, the metal sheath heater, and the quartz lamp. The infrared heat lamp is used largely for industrial process heating applications, although the R40 with built-in reflector, rated from 125 to 375 watts, is also used in some bathroom ceiling heating fixtures. Metal sheath heaters incorporate a resistance embedded in an electrically insulating refractory material and encased in a metal tube. The quartz tube consists of a coiled element supported inside an air-filled quartz tube, usually ⅜ to ¾ in. in diameter. The quartz lamp also uses a coiled resistor in a quartz tube; however, the tube is exhausted, filled with an inert gas, and sealed.

The metal sheath and quartz tube heaters normally operate in the 1200 to 1800°F temperature range, while the filament temperature of the quartz lamp is about 4000°F. In general, the higher the temperature, the greater the percentage of radiation. However, increased temperatures also increase the percentage of visible radiation; hence the quartz lamp would not be selected where the visible output would be objectionable. The metal sheath heater is the most rugged and gives the least visible light. On the other hand, the quartz lamp can often serve as a source of both heat and light where required. All three types require suitable fixtures and reflectors to direct the heat.

Typical ratings of metal sheath heaters and quartz tubes range from 800 to 4000 watts at standard voltages from 120 to 480. Quartz lamps vary from about 200 to 5000 watts for operation at voltages ranging from 60 to 1000 volts. All three types are normally designed for a specific watts/in. density, hence the length of heating element will vary with the wattage.

Controls

Thermostats. These devices perform a simple on-off function to control the output of a heater. They may be built into the heater or they may be wall-mounted.

Built-in thermostats open and close the circuit to the heating element in response to the temperature of the air passing through the heater, as measured by a sensing bulb in the air stream. Their use may be well suited to an application where rather rapid response to sudden drafts is desired; where a suitable location is not available for a wall-mounted thermostat; or where maximum economy of installation is of prime importance.

Wall-mounted thermostats may be of the line-voltage or low-voltage type. The contacts of the line-voltage thermostat open and close the circuit to the heater in response to the action of either a bi-metal or liquid-expansion element. The element may be sensitive only to the temperature of the ambient air at the thermostat, or the construction may be such as to permit the integration of the air temperature and radiant heating effect resulting from ceiling cable or other heaters having a predominantly radiant output. Low-voltage thermostats act as a pilot device to operate a relay which in turn energizes and de-energizes the heaters. More accuracy of control is usually ascribed to the low-voltage thermostat, since its contacts need not carry heavy circuit currents and thus may be designed and constructed with more precision. The additional cost of the relay must be weighed against the temperature control gained.

Demand Controls. Extensive metering of electric heating loads by power suppliers has shown that such loads do not add to the system peaks nearly so much as was feared initially; hence most utilities do not require any special regulatory controls to limit the simultaneous load. However, demand limiters are available for use where required. They may also be installed in the interest of the consumer to limit the load and reduce operating cost where demand charges are included in the rate structure, or to permit the connection of additional equipment to a service which would otherwise be too small.

Operation depends upon a sensing unit which trips a relay when the system current reaches a predetermined value, the relay switching the heating load from full to half voltage. This cuts the connected equipment to 25% of its full-load wattage rating. Periods of peak load are usually of comparatively short duration, and little if any inconvenience is caused by the reduction in heating capacity.

Modulating Controls. This type of temperature control, used chiefly with central furnaces and auxiliary resistance heaters associated with heat pumps, connects the load in stages as it is required. A typical unit uses a low-voltage thermostat with SPDT-type contacts which controls the operation of a slow-speed reversible motor. Through the action of cams on the motor shaft, a series of switches (usually 2 to 8), each connected to an independent resistance element, are opened or closed according to the amount of heat required. Controls of this type are also described as "proportioning" or "integrating" controls.

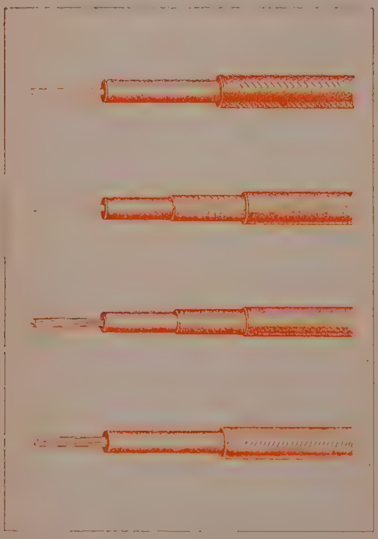
Set-back Controls. In many buildings considerable operating economy can be effected by reducing the air temperature during unoccupied periods in all or a portion of the heated space. This is especially true where the time of occupancy is relatively small compared to the time the building is not in use, such as schools, churches and other institutional buildings, and some office buildings. For large installations, 7-day time switches with suitable by-pass switches are extensively used. Residential low-voltage thermostats are available with built-in heating resistors which automatically reduce the control point by several degrees in accordance with a preset clock.

WIRE & CABLE

Intelligent selection of wire and cable is by no means a simplified process, as evidenced by the fact that the code lists more than two dozen basic types of insulated conductors for application within specified operating and temperature limitations. Moreover, manufacturers offer countless variations of insulating and covering compositions, while additional distinguishing features of construction and protection further extend limits of selectivity.

It is essential to consider related operating and installation factors. For example: Will cables be subjected to corrosive atmospheres (and what kind)? How about chemical seepage (what chemicals), or electrolytic corrosion? Will they be installed in "hot spots" such as boiler rooms or for high-temperature processing operations? What will normal ambient (surrounding) temperatures be, and what will operating or "working" temperatures of the cables themselves be? Will cables be subject to mechanical abuse, or will limited space for routing or terminating cables limit their dimensions? Is there a possibility of flooding in underground ducts or manholes, and if so, what type of flooding is possible? Will it be water only, or infiltrations contaminated by salt brine, oil or gasoline?

As to installation considerations: Will circuits be contained within conduits or wireways, or buried directly in the ground, or installed in vertical shafts, or supported as aerial feeders? And, pertaining to electrical operating requirements: Will systems be grounded or ungrounded? What are phase-to-phase working voltages? What are anticipated loads in kva and amperes? And what are anticipated load factors?

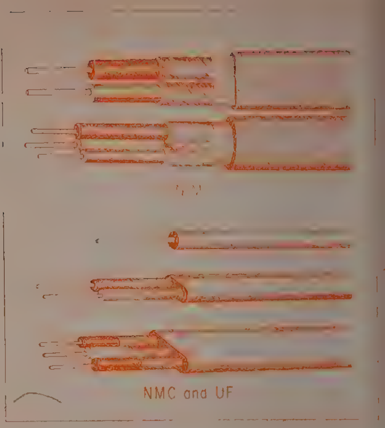


BRAIDED RUBBER INSULATED building wire is available with solid or stranded conductors sheathed with single or double fiber covers as indicated above. Selection considers such factors as uniform diameters, tightly adhering braids and wax coatings to facilitate pulling; bright scuffproof colors to quickly identify circuitry; clean stripping insulation, also flexibility or ductility to obtain good connections.

Selecting Conductor Size

Selecting conductors for branch circuits involves design considerations such as (1) rating wires at least 25% greater than load currents when loads operate continuously over long periods, such as general lighting circuits in commercial buildings; (2) rating conductors for individual motor circuits at least 25% greater than motor full-load currents; (3) derating current-carrying capacities of conductors (according to correction factors contained in NEC Secs. 310-12 through 15) when more than three conductors are grouped in the same raceway; also (4) sizing conductors sufficiently large to keep voltage drop and power losses to a minimum, modern design dictating that branch circuit voltage drops be limited to 1%.

It is well to remember that capacity does not by itself dictate conductor size, since final selection is also contingent upon such additional factors as voltage drop and regulation, temperature rise within limits of insulations selected, reasonable energy losses and adequate cross-section areas to accommodate short-circuit heating. Size of cable assemblies also will be affected by conductor metal selected (copper or aluminum), and, if conductors are stranded, they may vary in size due to methods of assembly; various compacting operations making them smaller (as well as stiffer and springier, due to hardening action).



NON-METALLIC SHEATHED cable (NM) may be obtained with one or more conductors, with or without ground wire, insulated with thermoplastic or rubber, covered with paper and braid. Designed for open or concealed lighting or power circuitry in reasonably dry locations, it is recommended for interior wiring and major appliance circuits. Its corrosion-resistant counterpart (NMC) has excellent water, fungus, flame and corrosion resistance which permits its use in moist, wet or corrosive atmosphere. Underground feeder and branch circuit cable (UF) is available in 1-, 2- or 3-conductor construction, and, with special outer coverings, may be used as a feeder or branch circuit cable when provided with overcurrent protection not in excess of rated current, carrying capacities of individual conductors.

Insulation Selection

Insulations (the second of three selection factors) are designed to accommodate temperature rise (ambient plus load-induced heat); to resist environmental conditions (such as moisture, fumes, chemicals, oil and grease, acids or alkalies); to promote installation ease; keep costs of installation, maintenance and replacement within reasonable limits; and to insure efficient, reliable service by providing proper physical and electrical properties.

Outer coverings (the third of the selection factors) likewise must satisfy environmental conditions listed above, and must also resist such "innocent" deteriorating agents as sunlight and air. In addition they must withstand abrasion,

Wire and Cable Definitions

ACSR—Aluminum conductor steel reinforced; aluminum wires stranded around a steel core.

ASTM—American Society for Testing Materials.

AWG—American Wire Gage; the measurement universally applied in the U. S. to designate sizes of wires or conductors; numbers are retrogressive, with larger numbers defining smaller wire sizes.

Braid—Woven coverings used on some types of insulated wires to provide some mechanical strength and to serve as a means for identification.

Bunch Stranding—A collection of wires or strands twisted together in the same direction without regard to geometrical arrangement.

Buna Rubber—Man-made rubber used as replacement for natural rubber.

Butyl Rubber—Man-made rubber with excellent resistance to heat, sunlight, weather, aging and ozone, used for special applications.

Cable—A stranded insulated single conductor or an assembly of insulated conductors usually with an outer covering. Small single conductors are often called wires, and small flexible cables are called cords. Numerous deviations from these definitions result from traditional trade names of items in long-time acceptance.

Cable Core—The portion of an insulated cable lying under a protective covering or coverings.

Compact Conductor—A stranded conductor which is rolled to deform round wires to fill normal interstices between wires in a strand; wires generally are laid in the same direction.

Coverings—Usually refers to braids (fibrous coverings) or tape or jute servings, etc., placed over the outside of an insulated conductor.

Conductor—A wire or group of wires uninsulated from one another, suitable for transmitting electric current; may be bare or insulated as a unit.

Current Carrying Capacity—The maximum current a conductor can carry without heating above safe designated limits.

Duplex Cable—Two insulated conductors twisted together with no sheath or outer covering.

Dielectric—A meduim having such required properties that energy required to establish an electric field (voltage stress) is recoverable, in whole or in part, as electrical energy. A vacuum is the only known perfect dielectric.

Dielectric Strength—The voltage stress required to puncture a specimen of known thickness, expressed as volts per unit thickness.

Filler—Material used in multiple conductor cables to occupy interstices formed by the assembly of insulated conductors.

Grounded Neutral—A circuit operates with grounded neutral when the neutral is metallically connected to ground and there is a provision for immediate removal of a faulted element.

IPCEA—Insulated Power Cable Engineers Association.

Insulation—Any substance of such low conductivity that the flow of electrical current through it can usually be neglected.

Insulation Resistance—The resistance offered by the insulation of an insulated conductor to current flow from impressed direct current.

Jacket—An impervious outer sheath or covering over insulation, such as rubber, neoprene or resin.

Lay—The distance along a cable occupied by one complete helix of a strand or conductor.

MCM—Thousand circular mils; the circular mil area of a round conductor being obtained by squaring the diameter, measured in thousandths of an inch.

Neoprene—A man-made rubber having superior resistance to oils, alkalies, acids and most solvents, also has high abrasion resistance and will not support combustion.

Polychloroprene—Chemical name for neoprene.

Polyvinyl Chloride—PVC; thermoplastic resin.

Polyethylene—Thermoplastic resin for high frequency use.

Plastic—A physical condition characterized by permanent change of shape of a material upon application of force.

Self-supporting Aerial Cable—A cable consisting of one or more insulated conductors, factory-assembled with a messenger which supports the assemblage and which may or may not form a part of the electrical circuit.

Semi-conducting Jacket—A jacket having a sufficiently low resistance so that its outer surface can be kept at a substantially ground potential by a grounded conductor in contact with it at frequent intervals.

Sheath—An impervious covering over insulation, such as lead. (See jacket.)

Shielded Cables—Cables in which the insulated conductors are enclosed within an envelope of conducting material; the shield of conducting metal or other material being so applied that substantially every point on the surface of the insulation is at ground potential.

Solid Conductor—Composed of a single wire.

Strand—A single uninsulated wire used in combination with other strands to form a conductor.

Stranded Conductor—A group of wires or combinations of groups of wires.

Thermal Resistance—The resistance offered by the insulation and other coverings to the flow of heat from the conductor to the outer surface.

Thermoplastic—A physical condition in which the plasticity is increased by increased temperatures and decreased by decreased temperatures; any change of shape resulting from the application of force at elevated temperatures being permanent.

Tinned Conductor—A bare wire with a thin coating of tin which acts as a separator between conductor metal and insulation; also facilitates soldering the wire to a terminating connection.

Tracer—A thread or group of threads of contrasting color or size in a braid, a ridge or insulation surface, a colored stripe on insulation for the purpose of identifying polarity.

Twin Cable—A cable having two insulated conductors laid parallel with a protective sheath or jacket over them.

Triplex Cable—A cable having three insulated conductors twisted together without a sheath over them.

Twisted Pair—Comprises two insulated conductors twisted together without common covering.

Wire—A rod or filament of drawn metal, usually of circular cross section.

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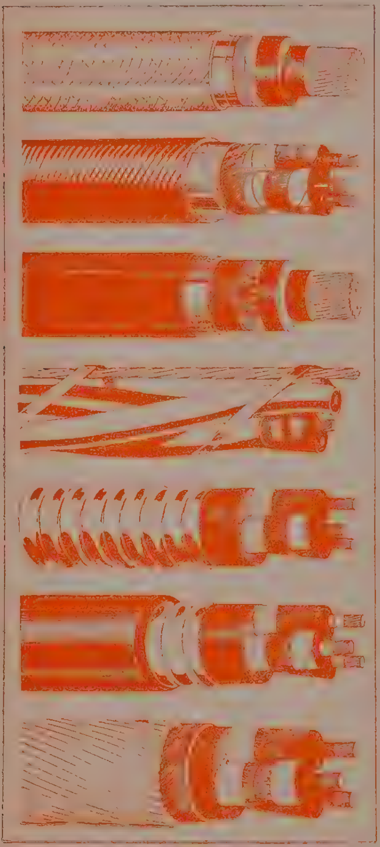
impact, or (when installed as additional protection for lead cables, for example), corrosion and electrolysis. However, although outer coverings generally are part of a cable's over-all construction picture, the code recognizes certain Type T and TW insulations as being sufficiently rugged in themselves to resist normal mechanical wear under normal conditions; therefore, such conductor assemblies are approved for use without additional cover protection.

Insulations considered most extensively for general purpose 600-volt wiring involve the rubber and thermoplastic "families." That is, for dry locations where maximum operating temperatures will not exceed 60° C (140F), conductors may be insulated with Code Rubber (Type R), Thermoplastic (Type T) or Latex Rubber (Type RU). Where higher temperatures are involved in dry locations, heat-resisting insulations such as RH, RUH or RH-RW are prescribed up to 75° C (167F), with Type RHH being specified where temperatures are in the order of 90° C (194F).

Where moisture may be encountered, general purpose wiring applications call for water-resistant insulations such as Types RW, TW, RUW or RH-RW where temperature ranges are normal, that is, below 60° C. Or, if temperatures in the order of 75° C are contemplated, insulations must fulfill additional heat and moisture requirements related to cable Types RHW and THW.

It is pertinent to mention that rubber insulations (manufactured with a variety of mineral, rubber or butyl bases) offer good overloading characteristics under normal conditions and are available in sufficient variety to satisfy numerous application and cost considerations, although auxiliary jackets are necessary if oil or heat conditions prevail.



PROTECTIVE COVERINGS are designed for varied applications; combining versatility and durability with economy and protection in accordance with intended purposes. For example, the assortment above includes (1) fibrous braids for normal mechanical protection when cable is pulled into conduit or where interior physical conditions are not severe. Cotton, jute, glass, asbestos and other materials are available either untreated or with flame-proof and moisture-proof saturants; (2) parkway cable, for direct burial in the ground where extra mechanical protection is desirable, has heavy flat metal tapes covered with asphalt-saturated jute in the above illustration; (3) lead with an outer impervious covering designed to resist corrosive, chemical or electrolytic action; (4) aerial self-supporting cable with inbuilt messenger; (5) interlocked metallic armor, which may be galvanized steel, bronze or other metal to provide mechanical protection in place of conduit; (6) armor sheathed with a vinyl outer covering to resist certain chemical corrosion conditions, and (7) armor wire to support as well as protect vertical risers or submarine cables.

Thermoplastics, however, have additional properties designed to improve toughness and to enhance resistance to moisture and chemical reactions. Also, since they do not require additional outer coverings, they take up less room in conduits. Being smaller in diameter, lighter in weight, durable and silicone lubricated, such thermoplastic-insulated wires and cables are easily handled and installed. This ease of pulling is an important consideration, so the use of thermoplastic wire and cable is understandably extensive for power, lighting and control circuitry, especially where moisture, chemicals or oils are present.

As temperatures and installation considerations become more exacting, insulation recommendations proceed to varnished cambrics (Type V), asbestos (A), minerals (MI) and combination thereof, such as Types AVA, AVB and AVL. Of these various insulation mediums, varnished cambrics, when considered separately, are prescribed for dry locations, with temperature permission going to 85° C (185F). Likewise, asbestos, considered alone, is limited to dry locations, although, under conditions stated fully in NEC Art. 310, temperatures may go to 200° C (392F). Insulation classed as Type MI is prescribed for wet as well as dry locations when special termination fittings are used, and, for certain applications, operating temperatures may go to 250° C.

Oil impregnated paper is yet another insulation medium and, when so approved, may be used for underground service where operating temperatures remain below 85° C. Like varnished cambric, paper is a high-grade insulation recommended for larger-sized or higher-voltage feeders, also large motor and generator leads. Paper has a definite cost advantage over cambric, although the latter may be terminated and spliced more easily. Paper, varnished cambric and cambric-asbestos in combination all have excellent overload and short-circulating heating capacities.

In many respects, varnished cambric insulation may be ranked between rubber and impregnated paper; this being true in regards to moisture and heat resistance, flexibility and dielectric strength, ease of installation, termination and splicing. More moisture resistant than paper, cambric may be installed in dry locations without protection of a lead sheath; although, unlike rubber, it does require a waterproof covering where continuous exposure to moisture is expected. In dielectric strength, varnished cambric is superior to rubber but not equal to impregnated paper. And, although cambric is not as flexible as rubber, cables so insulated are easier to handle than cables insulated with paper.

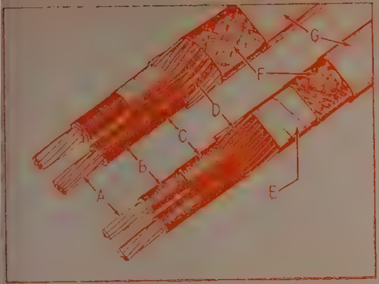
Many consider impregnated paper as a standard insulation for high-voltage operation and general power transmission, while rubber is prescribed for many low-voltage installations plus higher voltages when flexibility and moisture resistance are important factors. Between these two comes varnished cambric with properties that, under certain conditions, recommend them above either rubber or paper. For these reasons, cambrics are extensively specified for general wiring in power stations and within heavy industrial and manufacturing plants where blocks of power are large and distribution distances are relatively short.

As for asbestos insulated wires and cables, these assemblies possess established standards when exposed to severe operating conditions such as extreme heat, high humidity and overload conditions. Asbestos frequently is combined with other insulating materials to increase insulation resistance, dielectric strength and resistance to moisture. One of the more-widely used combination materials is varnished fabric which has excellent electrical properties and is "sandwiched" between layers of asbestos to protect it against high ambient temperatures or flame which the cable might be subjected to.

Since asbestos is an inorganic mineral, it withstands conditions which would deteriorate other materials, and, when applied to wire and cables, its low heat conductivity enables it to withstand even melting of copper conductors caused by overloads or shorts.

Protective Coverings

Since the best of insulations may be damaged or destroyed by physical abuse or environmental hazards, many types of protective outer coverings are available for consideration. Such coverings include numer-



SERVICE ENTRANCE cables may consist of either copper or aluminum phase conductors (A) covered by heat resistant insulation (B) and moisture-resistant braid or tape (C) color coded for circuit identification, while basic assembly is enclosed by concentric neutral (D). Unarmored Type SE, Style U is covered by variety of tapes (F) and outer braid (G) such as glass and cotton impregnated with moisture resistant and flame retardant finish labelled with pertinent data. Armored Style A additionally contains flat steel armor (E) as protection against physical abuse.

ous varieties of fiber braids; plastics (polyethylene or polyvinyl chloride, PVC, for example); lead (with or without additional protective coverings); rubber, neoprene or resins.

Braided coverings may be of soft saturated cottons, recommended for general use; or hard mercerized cottons, desirable for appearance; or asbestos or glass for heat resistance; or nylon for rot; or wire designed either for shielding purposes or to provide mechanical protection; such wire coverings including additional variables in steel, aluminum or bronze.

When fiber braided coverings are to be used for branch-circuit wiring, selection should consider such factors as whether wires are of small uniform diameters with snug braids and sufficient wax to facilitate easy pulling; whether braids are of bright colors to promote fast, positive circuit identification; also whether braid and insulation can be stripped cleanly and easily to facilitate connections or soldering operations.

Lead sheaths, being completely moistureproof and resistant to most types of corrosion, provide durable metallic coverings which formerly were an accepted standard whenever cables were permanently placed in moist locations. Present practice, however, is trending towards neoprene jacketing rather than lead, due to lighter weight, smaller initial cost and easier installation routines involved. Since such installations are not subject to undue disturbance after initial placement, flexibility is not a governing requirement in these instances, and such neoprene jackets generally need not be reinforced as a result.

Reasons for shielding insulated power cables are several, including (1) reduction of shock hazards to personnel, provided shielding is properly grounded, (2) protection of cables connected to overhead lines or otherwise subjected to induced potentials, (3) obtaining of symmetrical distribution of voltage stress within insulation, thereby minimizing possibilities of surface discharge, (4) containment of electrical fields within wire and cable assemblies, and (5) elimination of voids in critical stress areas due to alternate heating and cooling of cables in intermittent operations, thereby obtaining more uniform stress control.

Mineral-insulated metal-sheathed assemblies (Type MI) contain conductors insulated by highly compressed refractory materials which then are enclosed in liquid-tight and gas-tight flexible metallic sheathing. Use of MI conductors is permitted for exposed or concealed installations in wet or dry locations, under plaster or embedded in plaster finishes on brick or other masonry, exposed to weather or moisture, permitted underground, embedded in concrete or fill, approved for use in buildings under construction, also in locations subject to oil or gasoline or such other hazardous conditions that do not have deteriorating effects on metal sheaths, as defined by NEC Art. 330. Threaded MI cable fittings in standard conduit sizes and having standard conduit threads are available, and installation is facilitated by special sheath strippers and end-seal crimping tools.

Aluminum-sheathed cables (Type ALS) are factory assemblies of insulated conductors contained within impervious, continuous, closely fitting, seamless aluminum tubes, to be approved for installation conditions similar to those applying to MI, when installed in conjunction with appropriate connection and terminal fittings approved for such purposes.

Metalclad cables (Types AC, ACR, ACT, ACV and ACL) include all fabricated assemblies of insulated conductors and flexible metallic coverings approved for use in systems designed for 600 volts or less. Armored cables Types AC, ACH, ACHH and ACT (this category including rubber and thermoplastic insulated conductors contained, together with bonding strips, within wound and interlocked metallic armor coverings) are approved for general interior wiring except in moist areas or within block walls located below grade. Types ACV and ACR (armored cable with varnished cambric or rubber insulated conductors) may be selected for exposed, dry, industrial and commercial applications, while Type ACL (armored cable containing lead-covered conductors) may be used when installations are exposed to weather or continuous moisture, or underground, or where deleterious conditions such as oils or gasoline infiltrations are possible.

Where local codes permit their use, interlocked armored cables are desirable in order to bypass physical obstructions such as building columns, beams or wall offsets. Essentially consisting of insulated conductors, with or without additional protective coverings, and encased in flexible factory-applied metallic armor, such assemblies offer safety and protective features comparable with rigid metal conduit;

SELECTION of branch-circuit wiring should consider such factors as uniformity of diameter, outer coatings of wax or coatings of silicone to facilitate pulling, ductility and flexibility, color coding for ready identification, adequate current carrying capacities, insulations and coverings coinciding with electrical, chemical, physical, temperature and moisture conditions existing.

INTERLOCKED ARMORED CABLES offer safety and protective features comparable to rigid metal conduit; flexibility permits easy routing around bends and structural obstructions; they can be installed in long continuous lengths without intermittent joints or pull boxes, and they may be supported by variety of trays, troughs, ladders or hangers, thereby obtaining ready accessibility for inspection, tapping, rerouting or augmentation.

yet they lower installation costs since they minimize quantities of such items as pull boxes, do not require intermittent joint make-ups, eliminate pipe bending and fitting, and can be installed in long continuous lengths.

Again, variety of possible combinations is extensive, since conductor insulation and coverings may include rubber, varnished cambric, impregnated paper with braid, neoprene and lead jackets. And interlocked armor may be of galvanized or stainless steel, aluminum, bronze or zinc.

Armored cables also are available with outer protecting layers of helically-wound high-strength armored wire wrapped around assembled conductors; or armored tapes may be spirally formed around conductors to provide high impact resistance where great flexibility is not demanded; and, for applications in corrosive or electrolytic locations, armored cables defined above may be obtained with supplemental plastic or neoprene jackets.

Non-metallic sheathed cables (Types NM and NMC) are another classification of rubber and thermoplastic insulated conductors, with or without separate grounding conductors, with outer sheaths of non-metallic moisture-resistant flame-retarding materials. In this group, Type NM is prescribed for interior wiring, exposed or concealed, in dry locations only, where not exposed to corrosive fumes or vapors, or where not embedded in concrete, masonry, fill or plaster. Types NMC, which also are resistant to corrosion and fungus action, are approved for approximately the same applications, except that they may be embedded in plaster or installed in chases, provided $\frac{1}{16}$-inch steel plates are placed over them as protection against possible damage from driven nails, as outlined in Code Art. 336.

Service entrance cables (Types ASE, SE and USE) are assemblies of conductors, one of which may be uninsulated, installed within suitable coverings primarily intended for service purposes. In this group, Types SE have moisture-resistant flame-retarding coverings; Types ASE have the same characteristics plus inherent protection against mechanical abuse, while Types USE (approved for underground use) require outer coverings which need be designed to resist moisture only.

Underground feeder and branch-circuit cables (Types UF) include rubber and plastic insulations with outer coverings resistant to moisture, flame and fungus action. Prescribed for direct burial in earth, they may be used either as feeders or branch circuits when provided with suitable overcurrent protection, as dictated by NEC Art. 339.

Preassembled aerial cables are self-supporting assemblies obtainable in many combinations, such as single conductors used in single-phase ungrounded circuits where voltages are below 5-kv and where hard-drawn messengers can serve as ground returns; also 3-conductor assemblies, likewise designed for voltages below 5-kv; also single- and multiple-conductor assemblies designed for higher-voltage grounded-neutral services.

Economically, the initial cost of a preassembled aerial cable installation can be considerably less than underground construction. And, while it is basically costlier than open wiring, the total annual cost of self-supporting cables frequently is less due to permissible elimination of higher poles, extra hardware and tree trimming expenses. Therefore, where the expense of underground cable is not warranted, yet where open-wiring construction would not give complete satisfaction, preassembled aerial cables render definite service.

Copper vs Aluminum

Copper, the electrical industry's historical basic current-carrying conductor, is predominantly used in the electrical field for general industrial and commercial applications; a status which is well founded, since mechanical and electrical properties of copper make it ideal as a conducting medium. Not only does copper possess high electrical conductivity (exceeded in this respect only by silver), but it also is ductile, malleable, easily connected, tenacious and fatigue-resistant. It is highly resistant to corrosion and, when such corrosion does occur, it forms a thin adherent film of oxide or basic carbonate (patina) which protects the metal from further deterioration.

Aluminum, likewise, has advantages to recommend its selection for power distribution purposes, particularly for aerial or direct burial installations or where conductor sizes are larger than No. 6 AWG. Such advantages begin with weight, which can be as much as 50% less than equivalent copper services; also installation costs are reduced since more footage can be installed with fewer fastenings in less time. Aluminum wire and cables also are flexible, making them easy to bend and train and handle in complicated installations; they are ductile, making for fast installation.

RACEWAYS

Raceway selection covers a broad eld of conduits and ducts, cellular oors and underfloor duct systems, ireways and auxiliary gutters, oughs and trays. Points to be nsidered pertain to safety, acessibility, flexibility and adequacy -not only for present requireents, but to contain larger conuctors and additional circuitry to pe with load growth. Initial econmy is an important factor when electing distribution components, yet including excess capacity now to preclude costlier rewiring in the future is definitely practical.

SBESTOS CEMENT duct bank pictured bove incorporates flexible connections reduce settlement and shear stresses. ssembly was speeded through use of pered couplings; selection of long ngths reduced number of joints. Liberal election of standard fittings facilitates hanges in direction, duct sizes and duct-nduit transitions.

EIGHT FACTOR is labor-saving conderation, as evidenced by this installaon view where standard length of aluinum conduit is carried up ladder, oupled and strapped to rack by single an. Clean threads permit easy coupling y hand, with strap-wrench providing inal force to snug tapered conduit ends nto collars to establish positive electrical ontinuity.

Rigid Metallic Conduit

In considering raceways it is pertinent to first refer to rigid metal conduit, since this medium is the "granddaddy" of electrical distribution. Rigid metal conduits may be selected in sizes from ½ to 6 in. diam., and an extensive line of standard fittings and accessory components are available.

To comply with these various criteria, rigid conduit is available in steel, aluminum, bronze, copper alloys and wrought iron. Moreover, steel may be obtained coated with enamel or zinc, and zinc may be obtained with variations related to application processes such as (1) hot dip galvanizing, consisting of immersion in molten zinc, (2) electro-galvanizing, wherein zinc is deposited electrolytically, (3) sherardizing, by which steel conduit is heated in airtight chambers in the presence of zinc dust, or by (4) metallizing, with zinc powder sprayed at high velocities on steel surfaces. Zinc provides an effective barrier against corrosive moisture and inhibits rust.

In severely corrosive locations it may be necessary to coat rigid conduit with asphalt or plastic. It is important for those who select conduit to investigate not only conditions which initially prevail, but also conditions which might develop due to change of occupancy of property utilization.

One of the prime attributes of rigid metal conduit is safety. It affords maximum protection to: (1) persons against shock hazard by establishing paths of low electrical resistance to ground, (2) property against fire hazards which might possibly occur due to arcing of electrical conductors, and (3) electrical circuits themselves against corrosion, physical abuse, moisture and practically all other deleterious conditions.

Electrical Metallic Tubing

Another excellent wiring medium is EMT; available up to diameters of 2 in. and similar in many respects to rigid steel and aluminum conduit. However, being thinner-walled, lighter in weight and less ruggedly constructed, its use is necessarily restricted to locations where it will not be subjected to mechanical abuse. Moreover, its use is not permitted in hazardous locations and its service is limited to 600 volts. Regardless of such limitations, however, EMT provides considerable design versatility on a modified scale.

Electrical metallic tubing is not threaded at the ends and is generally installed with compression, indentation, set-screw or push-on types of couplings and connectors, although approved threaded fittings (intentionally differing from standard conduit thread dimensions) are also available.

If exposed to corrosive vapors or fumes, EMT and related fittings must be of corrosion-resistant materials, while dissimilar metals in the same system should be avoided if at all practicable.

Flexible Metallic Conduit

Although flexible metallic conduit has been in use for some 65 years, too often it has been classified as an auxiliary wiring medium to be used only for special applications, such as for installations subject to vibration or movement. Yet flexible metallic conduit is a practical, pliable, protective, pull-in wiring medium in its own right; to be considered as a useful separate raceway rather than as an accessory; and available in galvanized steel, aluminum, brass or bronze with or without special fittings, synthetic or metal braid coverings.

Reasons for its consideration as a raceway are numerous, since flexible metallic conduit has:

1) Compression strength and resistance to impact exceeded only by rigid conduit;

2) Adequate current-carrying capacity, when properly installed, sufficient to provide a suitable path to ground in event of a fault within the enclosure, thereby insuring prompt functioning of related circuit breakers or fuses;

3) Construction features which make it unlikely for condensation to accumulate within raceways; a fact to be considered where wide

temperature variations are prevalent; and

4) Application flexibility, making it possible to install any desired specialized insulated wiring to satisfy conditions of unusually high temperatures, moisture, oil or solvent fumes, or to install more or larger conductors (up to limits of permissible fill) to keep pace with load growth.

In addition, flexible metal conduit constitutes a duct system which is available in long, continuous lengths; may be pulled through openings or holes in joists and studs; requires a minimum number of fittings; eliminates bending and threading.

Variations of flexible metallic conduit include square, lipped and hooked interlocking details; may be obtained with outer jackets which are moisture-proof, liquid-tight and flame-resistant; can be installed in locations subjected to temperatures well above 200° F; are available with built-in copper ground; may be installed in corrosive, chemical and oil-subject locations, and are available in several classifications up to 6 in. in diameter.

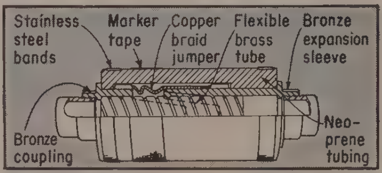
Flexible metallic conduit, when selected without auxiliary protective outer coverings, may not be installed underground or in cinder fill; in corrosive locations or where subject to severe mechanical injury; although, by complying with code-prescribed conditions, covered by Art. 350, they may be approved for certain outdoor, wet or hazardous applications.

Asbestos-Cement and Fiber Ducts

Consideration of the general conduit family should rightly include ducts of asbestos-cement, for this medium has wide acceptance for underground distribution, offers reasonable mechanical strength, is permanent and incombustible, is non-metallic and resistant to corrosion, cannot burn under short-circuit conditions, is unaffected by electrolysis and is impervious to rot or rust.

Wall thicknesses are available in standard and extra heavy sizes so that lighter components may be selected when duct banks are to be encased in concrete outer envelopes, and heavier ducts may be selected when only one or a few are to be buried in the earth. When concrete-sheathed, economy is achieved by selecting the lighter ducts.

DOUBLE OFFSETS are used to underpass heavy reinforcing bars installed along deep concrete beam line. Note insert cover recessions which later will be filled with material to harmonize with finished floor-slab treatment. Triple-cell duct system is supported and levelled by adjustable-height saddles prior to pour.



EXPANSION FITTINGS may be selected as vibration dampers and deflection mediums as well as to provide for movement between building sections or for expansion and contraction due to temperature changes in long conduit runs. Fitting diagrammed above provides for movement from the normal in all directions plus 30 degree deflection; is available up to 4 in. dia and may be installed in concrete.

FLEXIBLE METALLIC CONDUIT is available in various interlocking configurations, in galvanized steel, aluminum, brass or bronze, with or without special fittings, synthetic or metal braid coverings designed to resist moisture, heat and flame, chemical vapors, oil and corrosive atmospheres.

Selection should consider also the availability of tapered couplings to promote accurate alignment, to speed assembly routines, to permit slight direction changes to effect large-radius bends, and to prevent silt from infiltrating at these connection points. In addition, adapters, flexible connections, expansion couplings, curved segments and ells of various degrees are available.

Fiber ducts also are available in two wall thicknesses to satisfy the same installation conditions noted above. Fiber ducts may be obtained with diameters up to 6 in. in lengths up to 10 ft. Use of longer duct-lengths naturally reduces the number of joints. And, to obtain maximum compactness of duct banks, several manufacturers offer flush tapered couplings having the same outside diameters as the ducts themselves, so it is possible to eliminate all separation between cells, placing ducts in contact and conserving concrete as an over-all envelope.

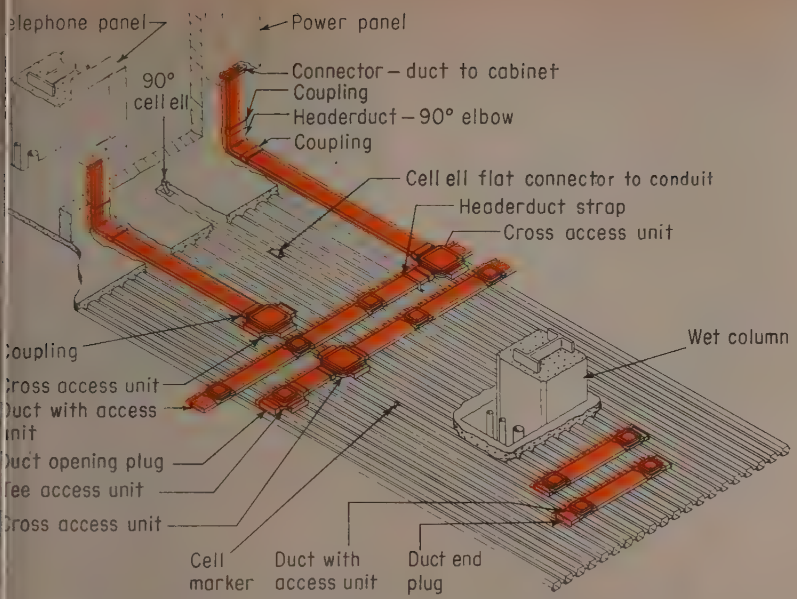
Plastic Conduit

While still relatively new as an electrical distribution medium semi-flexible high-density plastic conduit merits consideration for both underground primary (5 kv) and secondary distribution. Like the ducts just mentioned, plastic raceways are available in thin-wall standard and extra-heavy weights and are being selected (with loca inspector approval) for installations above ground and within buildings as well as underground.

Being considerably lighter than steel, aluminum, asbestos-cement or fiber, plastic conduits are easily handled; can be cut and threaded with standard conduit equipment fit standard-sized junction boxes and fittings; include a liberal assortment of plastic adapters, couplings, elbows, outlet and junction boxes; are normally assembled with slip fittings and fast-drying solvent welding cement, and may be bent on the job to desired shapes by first applying hot air to the section manually bending the then-pliable conduit as desired, and finally applying cold air to solidify the plastic.

Since plastic conduit has a certain amount of flexibility, underground installation can bypass exact grading of trench bottoms, conduit following ground contours within reason. And, having an inherent smooth finish free from sharp edges or burrs, wire is pulled in easily and safely.

When continuously supported or installed in moderate ambient temperatures, plastic conduit maintains good rigidity and alignment, although, when installed in locations of concentrated warmth (even in direct sunlight), thin-wall plastic conduit has a tendency to festoon



HEADER DUCTS may be installed on top of cellular flooring parallel or at right angles to structural cell members, with access boxes of various sizes to coincide with local wiring requirements. Diagram shows how power and telephone circuits can be routed longitudinally through floor cells, then shifted laterally via header ducts to bypass obstructions such as structural columns or riser shafts.

Underfloor Ducts

Numerous underfloor systems are available to fulfill various requirements. For example, self-contained duct systems (metal or fiber) may be obtained as single-, double- or triple-cell runs which can be installed on one or more levels with junction boxes and inserts providing frequent access openings whereby wiring may be connected to surface outlets as required.

In selecting junction boxes it is pertinent to check for strength and weight to satisfy installation and usage criteria; dimensions and tolerances of related parts to insure snug fits so as to preclude binding and exclude moisture; duct composition or coatings to resist corrosion, acids, alkalies and abrasion; leveling screws for boxes, rings and caps; easy accessibility to all cells; gaskets where waterproof sealing is desired. And, in selecting ducts themselves, check for smooth interiors and insert shoulders free from burrs; loosened inserts or collars; clean sharp threads to facilitate attachment of surface outlets. Review accessory catalogs to select necessary elbows, couplings, conduit takeoffs, adapters, expansion fittings, cabinet connectors and duct supports. Also relate ruggedness of surface outlets, dual fittings, receptacles and cover plates to practical design features.

Cellular Flooring

Electrical distribution can also be effected by utilizing the interstices of cellular (metal or concrete) flooring. And, since available raceways then are related to the over-all basic construction of the building itself, the number of cells is practically unlimited.

Header Ducts and Trenches

To connect service-grouped cells with distribution panels related to those specific services, header ducts may be installed directly on top of and at right angles to the cellular pattern; appropriate matching access holes in header ducts and floor cells permitting wire to pass from one to the other. Large-area covers (round, square or oblong) set flush with finished floorslabs provide ample access to header ducts to facilitate wire pulling and fishing; while waterproofing of the various systems is insured by appropriate caps over cell and duct ends, gaskets around accesses, sealing and coatings at union points.

Also available for consideration are total-access underfloor trench systems, with continuous cover plates easily removable to expose completely open trenches for maximum wiring flexibility and facility. These trench sections may be used independently in the same general manner as underfloor ducts, or they may be used in conjunction with cellular metal floors to render the same general service as header ducts.

Header ducts or trenches also may be considered for application with concrete cellular floors. However, since floor cells then are nonmetallic they may not be used as the basic grounding medium, and it is necessary to install additional grounding wires and appropriate connections to bond receptacles and floor inserts to headers which, in turn, must be electrically bonded to distribution panels and electrical feeder raceways.

As defined by Code Arts. 354, 356 and 358, cross-sectional areas of conductors contained in underfloor raceways, also in cellular metal and concrete floor raceways, cannot collectively exceed 40% of such cells; although this limitation does not apply when cells are used to contain only armored cable or nonmetallic sheathed cable.

Wireways and Gutters

Electrical wireways and auxiliary gutters consist of totally enclosed metal ducts, troughs or custom-built assemblies having cover plates which may be hinged (flanged or flangeless), snapped or screwed into position. Since wireway covers are continuous for entire assembly lengths (except where wireways are carried horizontally through dry walls, as permitted by the NEC), maximum access to wire and cable at all points throughout such installations offers unlimited facilities for circuit splicing, rerouting, tapping, inspection or addition of extra circuits without disturbing already-installed wiring. And, since wires are laid in place, rather than being pulled, protection against possible insulation abrasion is unexcelled.

Selection of cross-sections may be made from such standard sizes as 2½ by 2½, 4 by 4, 4 by 6, 6 by 6 or 8 by 8, while section lengths are obtainable in 1-, 2-, 3-, 4-, 5- and 10-ft standard units. Non-standard dimensions also are available when required for special applications, so it becomes possible for designers to obtain enclosed wireways to satisfy local wiring conditions.

While wireways are code-excluded from use where mechanical abuse or corrosive atmospheres are possible, they have many desirable features when installed in exposed,

METERS ARE GROUPED neatly above series of auxiliary gutters which effectively extend wiring facilities of central control cabinet. Screwed covers may be removed when access is necessary,

SELECTION of hinged-cover wireway sections, angles, tees, and closures, couplings and supporting brackets establishes continuously-accessible raceway for this compact panel assembly.

dry locations. And, although they are excluded from hazardous areas, they may be approved for use outdoors, provided their construction is raintight and prescribed for such locations.

Standard sections generally are factory-provided with end couplings which serve to unify wireway components into rigid, coordinated installations, serve to hold conductors in position pending installation of covers, and also lessen strains upon hinges, latches and screws.

Concentric knockouts are provided at close intervals along wireway walls to permit outlets and extensions to be located conveniently. And, in order to obtain exact routing or service configuration, accessory fittings may be selected from assortments of various-degree elbows, and caps and closure plates for discontinued openings, expansion couplings and telescopic fittings to adjust for exact dimensions, tees and cross-through sections, pull boxes and reducing bushings, adapters and connectors. In addition, a large selection of suspension methods makes it possible to install wireways from walls or ceilings with covers located along sides, bottoms or tops of runs.

When used as auxiliary gutters to supplement wiring space at distribution and meter centers, switchboards or similar interior wiring centers, wireways provide commendable wiring capacity, although (as defined by Code Art. 374) they may not be used to directly support or contain switches, overcurrent devices, apparatus or appliances. Auxiliary gutters (except for elevator applications) are limited to lengths of 30 ft beyond the equipment they supplement; covers must be securely fastened, and intervals of support may not exceed 5 ft.

Since auxiliary gutters frequently are custom-built to conform with special job conditions, the code prescribes construction details quite explicitly; stating that assemblies must be completely enclosed; with surfaces (interior as well as exterior) treated to resist corrosion; with rounded bushings, shields or smooth fittings located wherever conductors might pass between gutter sections or around bends, through partitions, into junction boxes or cabinets; and sheet metal must be at least 16 gauge when any section has a width exceeding 6 in.; 14 gauge when such widths go to 18 in.; 12 gauge with widths up to 30 in., and 10 gauge when widths are still greater.

Where essential to exclude moisture, dust or oil from enclosures, seams should be welded and covers gasketed and clamped.

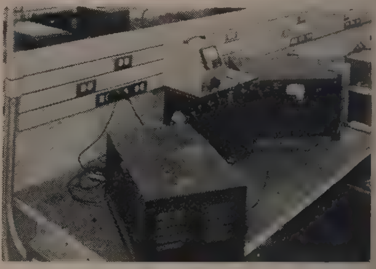
Wireways and auxiliary gutters alike are limited to 600-volt applications, with fill limited to 20% of cross-sections, and with not more than 30 conductors contained at any cross-section of an installation (except in cases where wiring consists of motor controller conductors used for starting purposes only).

Surface Metal Raceways

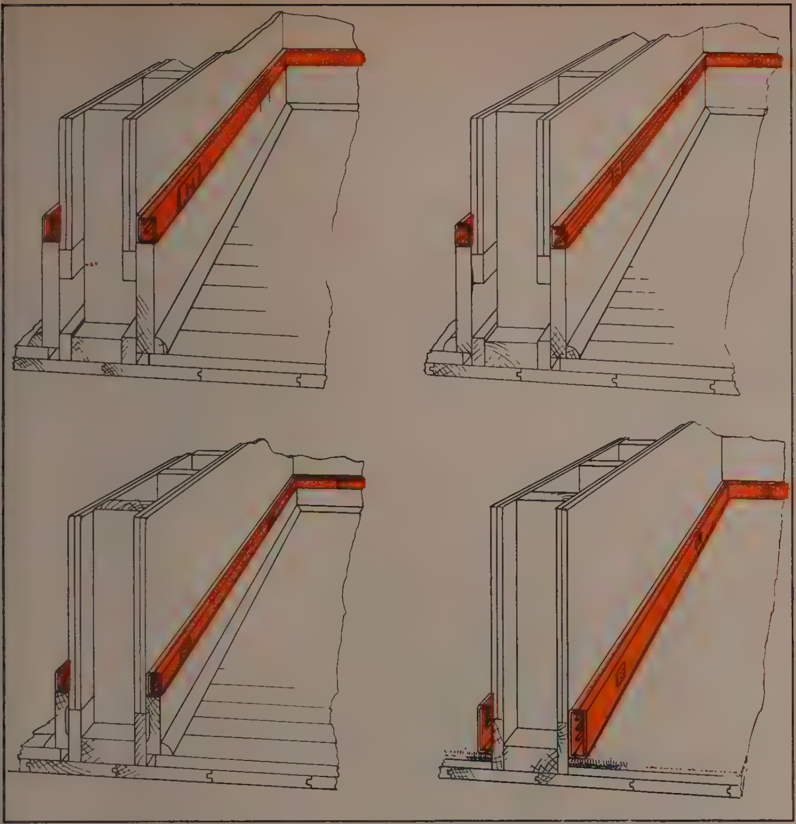
Advantages of surface metal raceways and multi-outlet assemblies are similar to those associated with wireways in general. However, due to their inherent qualities of compactness and lighter construction features, their applications are accordingly restricted. The National Electrical Code specifies that no conductor larger than No. 6 be contained therein and that voltages be not greater than 300 between conductors, unless enclosure metal is .04 in. in thickness or greater. The code further dictates that surface metal raceways and multi-outlet assemblies can be installed only in dry locations where not subjected to severe physical abuse or corrosive vapors; thereby precluding their use in hazardous areas and hoistways.

In general, such raceways cannot be concealed, although sections approved for the purpose may be used as underplaster extensions; metallic raceways may be partially embedded (back and sides) in walls; non-metallic assemblies may be recessed into baseboards, and unbroken lengths of raceways may be carried through dry partitions, walls and floors, provided covers are installed on all adjacent, accessible sections, and no outlets fall within confines of walls or floors themselves.

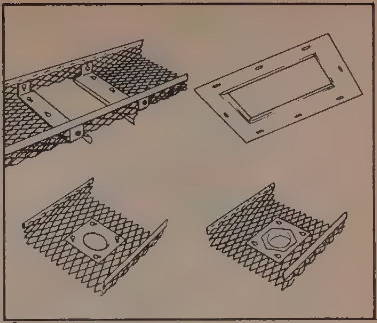
Selection of surface raceway components includes numerous shapes and sizes of cross sections; compact assemblies having widths and depths of less than ½-in. to meet minimum single-circuit requirements, with progressively larger assemblies providing up to 4 sq in. of interior wiring space in one or more compartments which may be covered separately or by a single, wide, common cover which contrib-



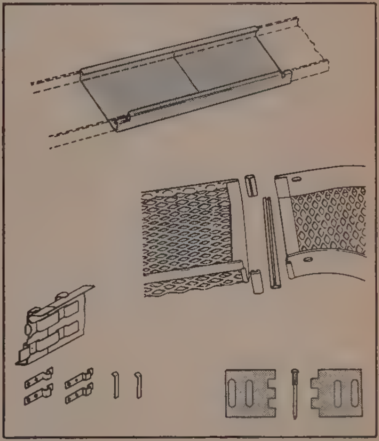
MULTIPLICITY of outlets required to handle diversified testing equipment in a magnetics plant dictated installation of four banks of surface metal raceways along backs of four 30-ft long benches. Bottom two runs are 120-volt 60-cycle single-phase service for instrument and test lines, while third line provides 115 volts single-phase current at 400 cycles, also for test purposes. Fourth line provides for a future patch system. Ivory receptacles and stainless steel flush plates are easily seen against grey finish of surface raceways. Note branch sub-panel at near end of bench, with end fittings for service connection of upper two raceways.



RESIDENTIAL USE of surface metal raceways initially considered channels having same depths as baseboards, with outlets either wired on jobsites (often resulting in too few outlets and high labor factors) or wired as fixed-interval assemblies at the factory (which disregarded furniture arrangement and flexibility). More recent trends have included duplex receptacles, 3-wire circuiting and raceways having contours to harmonize with numerous baseboard designs. Present trend is to have raceways serve dual purpose as wiring medium and baseboard, with multi-outlet metal assemblies combining electrical adequacy and convenience with modern, trim appearance and safety.



DROP-OUT openings for cables may be full width of cable trays or rectangularly framed, round or nippled to permit attachment of conduits.



CONNECTION of cable tray and trough sections is accomplished variously by splice plates, pins, bolts or clamping channels which may be installed quickly and easily with common tools such as hammer, pliers or wrench.

utes to over-all appearance and simplifies the wiring procedure in general.

The larger raceways are applicable for many industrial, research or repair shops, where circuitry serves numerous electric tools, small motors, heating units or testing devices. And, for modernizing office space, it is possible to install bevelled-edge "pancake" types of surface raceways to carry power, lighting or telephone service across floors, without requiring channelling and without introducing serious tripping hazards.

Surface metal raceways and multi-outlet sections are neat in appearance and relatively inexpensive; sturdy in construction and simple in design; tamper-resisting and safe; quickly installed and accessible. They provide practical solutions to modernization problems, such as serving additional outlets from previously-installed remote supply sources, and they also constitute readily-accessible wireways for electrical services subject to expansion or rearrangement.

Ventilated Cableways

Many modern electrical installations involve multiplicities of power and control cables. And, to make maximum use of limited space, conventional wiring methods sometimes are bypassed in favor of supporting wires and cables in quantities in accessible, flexible, ventilated trays, troughs, ladders, baskets, racks or trusses. When properly installed, spaced and protected, such cableways have distinct advantages.

While cableways are not intended for use as general purpose raceways, their installation should be governed by applicable raceway provisions, as outlined in NEC Arts. 250, 300 and 310. Moreover, since ventilated assemblies do not in themselves completely protect wires and cables from fumes, heat, moisture or similar deleterious conditions, their use should be limited to the support of such wiring mediums as mineral-insulated metal sheathed, armored, non-metallic sheathed, service-entrance or underground feeder and branch circuit cables. They also may be used to support raceways.

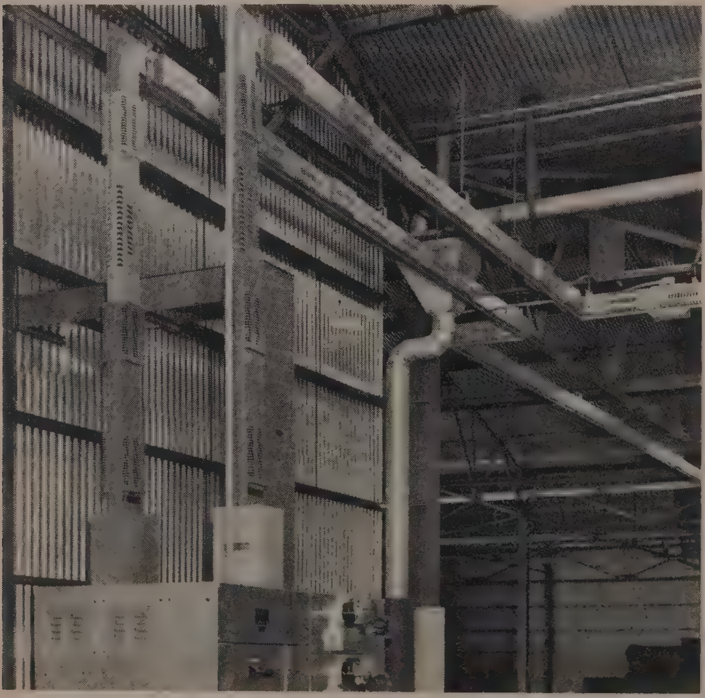
The several ventilated support mediums permit ready inspection, rearrangement, maintenance and augmentation of circuitry. Light in weight and open in construction, they likewise provide ventilation and cleanliness. Obtainable in steel or aluminum with various surfacing treatments, they combine corrosion resistance with high heat reflectivity and strength. And, when it becomes expedient to protect cables against the possibility of falling debris, excessive dirt or dripping moisture from above, trays and troughs may be covered with solid, louvered or expanded metal top plates.

BUSWAYS

Busways basically consist of "current-carrying conductors supported by insulators within metal enclosures." This definition encompasses considerable latitude. For example, conductors may vary in composition (copper or aluminum); cross section (rectangular, oval or beamed; solid or hollow) or configuration (phase bars grouped or interleaved). Conductors also may be bare or insulated, with surfaces silvered at joint connections and power tap points to minimize contact resistance at these locations only, or bars may be silvered for their entire lengths.

Enclosures similarly may be fully ventilated, totally enclosed or constitute combinations of these conditions. Conductor supports likewise may vary in composition, design and spacing, depending upon engineering concepts and intended alignments (horizontal or vertical) of busways. Casing contours likewise are numerous, dictating use of equally numerous types of hangers and brackets for support. And, depending upon materials used and construction details, spacing between supports may be modified in accordance with rigidity and weight considerations.

Busway variations also relate to intended use. For example: Is an installation to be indoors or outdoors? Is it to be used as a point-to-point feeder or as a distribution medium to permit power take-off devices to be positioned as desired along its length (plug-in)? Is it necessary or desirable to minimize reactance and voltage drop? Are power take-off devices subject to movement (trolley)? Are busways intended to serve intermittent high-amperage demands (resistance welding), or is it their purpose to carry high-frequency currents (in some cases up to 20,000 cycles) for applications such as high-frequency fluorescent lighting induction heating, electronic or laboratory processes. These and othe considerations introduce so man variables that selection and application possibilities are almost limitless for transmitting power at 60 volts or less.



LOW IMPEDANCE totally-enclosed busway carries power from outdoor substation to interior switching center, with subsequent in-plant distribution utilizing ventilated busways as shown. Note variety of edgewise and flatwise elbows, trapeze and clip-on hangers that snap into ventilation slots.

Application Scope

Ruggedly constructed, uniform in component duplication, easy t install and obtainable with configurations and characteristics t meet most demands of secondary power distribution systems, busways merit serious consideratio for many applications.

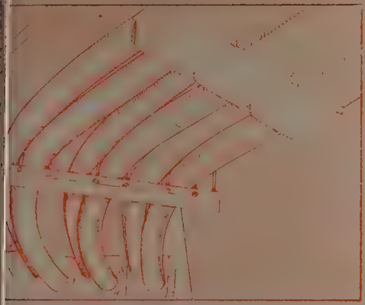
Busways are used for feeders between main power supply sources and transformers, switchboards distribution centers or terminals for plug-in busway continuations Used for such purposes, feeder busways are recommended for carrying power vertically to upper-floor control and distribution centers in high commercial structures, public buildings and institutions, as well a running laterally to switchgear substations or major distributio points in industrial plants.

Where current densities are high and maximum power distributio efficiency is essential or desirable busbars may be interleaved in orde to achieve minimum reductions i voltage levels; such arrangement resulting in lowered impedance du to balanced phasing conditions.

While feeder busways are not intended to accommodate intermitten branch taps, fixed-location powe take-off provisions may be obtaine by locating tap boxes at joints between standard-length sections.

Busways find wide application fo plug-in distribution mediums, wit power-tap provisions uniforml spaced at frequent intervals, s that insertion of take-off device permits great flexibility in locating or relocating machinery an electrical equipment. Branch circuits then can be established a easily and quickly as in open-wir systems, yet maximum personne safety and physical protection i provided by conductor-enclosing housings.

Busways are used for movabl power sources, wherein sliding o rolling trolleys can "follow the jo along continuous outlets," making it possible to feed production-lin portable tools, cranes and hoists mobile lighting units and similarl shifting loads, without requiring



EXIBLE CONNECTORS with busway atchments at either end simplify routing oblems, since flexible unions accommoite expansion, eliminate necessity for ecial elbows and transpositions, and rmit offsets or random angles to byiss obstructions or change direction at ll.

ng extension cords or accessory iring.

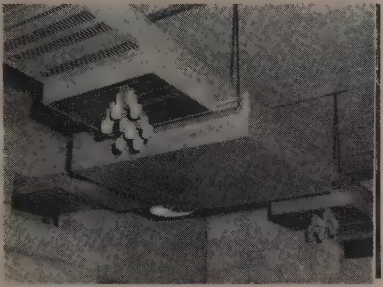
Since trolley busway sections are vailable in curved as well as traight units, and are light in eight and easy to install, layouts ay be designed functionally to ypass obstructions or to follow ractically any desired contour. nd, since trolleys may be disconected and reinstalled by simple rocedures, they constitute movable ranch-circuit outlets which can e relocated quickly to bypass other rolleys or to be shifted to other rolley busways if so desired.

Components and Accessories

In addition to straight busway ections, wide assortments of comonents and accessory power takeff devices are available to satisfy n almost limitless variety of layout onditions. Included in this category are elbows, tees, crosses and ffsets in both flatwise and edgevise configurations, available with ither copper or aluminum conducors. There also are end closure ections to prevent accidental conact with busbars by personnel; also to protect the bars themselves. Cable tap boxes are available for either end or center feed-in or takeoff of conductors contained within rigid or flexible conduit, while expansion joints compensate for variations in expansion and contraction of building structures or (in long straight busway installations) of the busways and bars themselves.

Liberal assortments of flanges also are available for use when busways pass through walls or partitions, flat or inclined roofs, curbed or flat floor slabs. Flanged end connections and busbar stubs are also used to directly join busway throats to switchboards or transformer tap openings, or flexible housing sleeves and braided current-carrying connections may be inserted between busbar and transformer secondary load terminals to isolate vibration and hum from distribution systems at these initial points. And, where low-reactance busway characteristics are to be obtained, transposition sections are available wherein phase bars are grouped at one end for terminal connection and then are rearranged so that bars of dissimilar phasing are balanced as described previously.

Since various manufacturers offer straight busway sections in standard lengths between 1 to 10 ft installations may be "tailored" to closely coincide with desired layouts. In addition, adjustable-length sections are available whereby exact dimensions may be obtained simply by loosening bus and housing clamp bolts, adjusting sliding components, then retightening the bolts. This feature speeds installation routines and simplifies design procedures by insuring exact field dimensions and eliminating possible delays relating to delivery of special rigid fittings.



MULTIPLE PHASE BARS are herein grouped and connected to lugs to accommodate leads dropping to switchgear assemblies.

The trend towards installation simplification also is evidenced by the introduction of fewer-bolt clamps that simultaneously connect adjacent busbars and housings; this same connection feature permitting maintenance men to retighten bolts without de-energizing the systems, and also permitting a slight movement of busbars; thereby compensating for differential expansion between bars and housings and eliminating the necessity for conventional expansion sections.

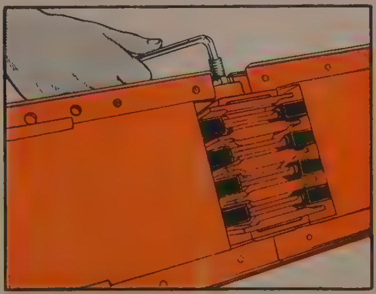
Flexibility and simplification of component connections likewise is possible through use of short, flexible armored cable sections fitted with suitable busway attachment boxes. Since such flexible connections are obtainable in various lengths and may be twisted or bent into limitless patterns, their use permits elimination of elbows, offsets, expansion fittings, switchboard connections and transpositions.

At points where large-capacity feeder busways feed smaller-capacity branch-circuit runs, adapter boxes containing fuses, circuit breakers or combinations thereof may be specified while either fused or non-fused adapters also may be obtained for progressively reducing amperage capacities of long busway installations.

As to plug-in or clamp-on busway devices, possibilities include capacitor plugs, a convenient means for reducing inductive losses and improving power factors of distribution systems; transformer plugs designed with or without magnetic contactors, designed, for example, to furnish single-phase current at reduced voltage from 3-phase 3-wire busways; ground detector plugs, with resistors located between busbars and grounded casings, and with low-wattage lamps mounted outside cubicles to give visual indication of grounded phase conditions; also temperature indicating plugs.

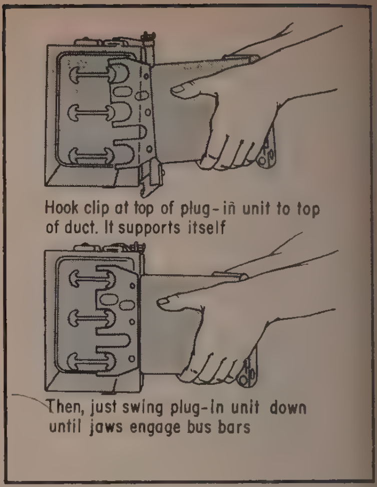
Code Limitations

Availability of busway sections, accessories and take-off devices in such profusion, however, does not constitute "carte blanche" permis-



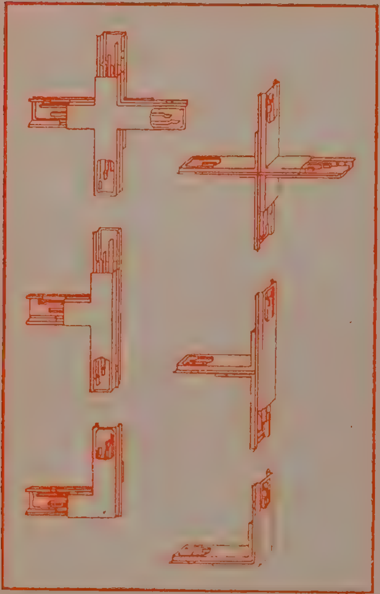
SINGLE BOLT, tightened by key wrench, exerts ton of pressure upon silvered interleaved busbar contact surfaces, assuring positive electrical contact. Busbars, separated by arc-resistant insulators, are clamped by stacked spring washers. When tightened, bolt is practically flush with housing flange, permitting inspection from floor and tightening of bolts while system is hot. Connection likewise accommodates differential expansion between busbars and housing.

TROLLEY BUSWAY constitutes continuous outlet, permitting power take-offs related to movable tools to be shifted as desired, and allowing lighting fixtures to be suspended and connected in flexible, functional patterns. Wide variety of simple suspension methods, fast connection of busway sections and easy insertion of trolleys contribute to multifunction distribution system.


Hook clip at top of plug-in unit to top of duct. It supports itself
Then, just swing plug-In unit down until jaws engage bus bars

HOOK AT TOP of plug-in device clips to top of busway housing to prevent possibility of unit dropping during subsequent connection operations. Hook also serves as fixed fulcrum to insure proper alignment of device with take-off.

sion to install busways in all locations or to solve all secondary distribution problems. For example, as defined by Section 364 of the National Electrical Code, busways only can be installed exposed, and then only in non-hazardous areas, or where not subject to corrosive vapors or severe physical abuse. Similarly they cannot be installed in hoistways, in wet or damp locations, or outdoors unless specifically designed and approved for such applications.



DESIGN OF BUSWAY installations are simplified due to liberal selection of flatwise and edgewise elbows, tees, crosses, end closures, tap boxes, adapters, flanges and straight sections which may be obtained in fixed or adjustable lengths.

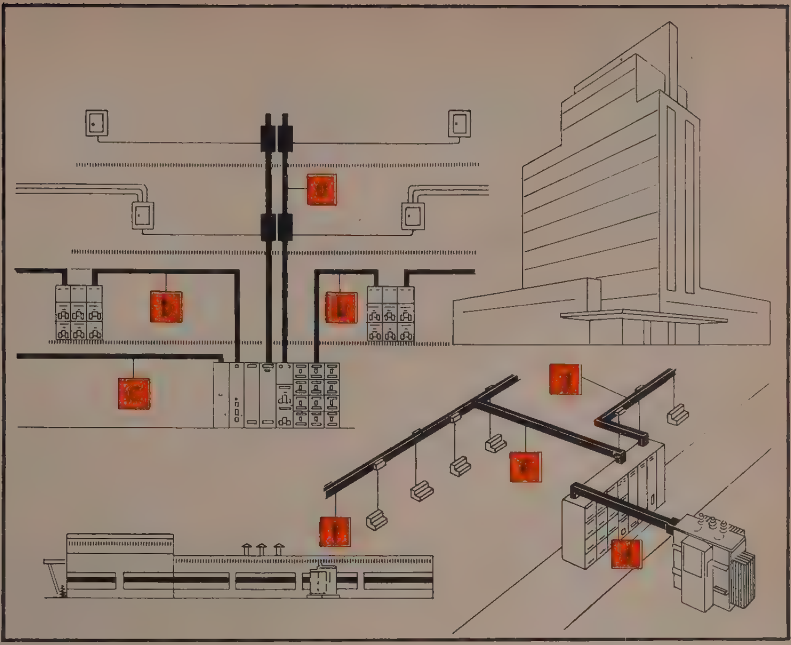
The code permits use of busways as service entrance mediums and also permits wide latitude in the nature of branch circuits (including other busways, rigid or flexible metal conduit, electrical metallic tubing, surface metal raceways, armored cable or heavy-duty extension cords). Yet it simultaneously suggests that the length in feet of plug-in busways used as branch circuits should not (in general) exceed three times the amperage rating of the busways, and it prevents ventilated busways from being carried vertically through floorslabs; demanding that totally enclosed sections be used in such instances and continued for distances of 6 ft above floorslabs to obtain adequate protection against physical damage. Also, busways may be carried horizontally through dry walls, provided no joints or connections are located at those exact points.

Ratings and Weights

Since busways are produced by many manufacturers, each offering assortments of outdoor and indoor, ventilated and enclosed, low-reactance and conventional, feeder and plug-in, copper and aluminum bar assemblies, it is apparent that designers can select mediums to satisfy innumerable combinations of amp ratings, bar configurations, accessory devices, supporting means, section and fitting dimensions and weights. Moreover, special sections may be specified and obtained to satisfy conditions of unusual nature. And, while all busways are characterized by distinctive features, this fact generally does not preclude using different types and makes in combination to supplement each other in integrated electrical systems.

Due to this diversity it is neither feasible nor practical to herein include complete listings of all combinations of electrical and physical characteristics, although it may be generally noted that low reactance busways designed for indoor use may be selected in small-increment steps from 600 amps to 5600 amps with copper bars, or up to 5000 amps with aluminum buses. Similarly, the ampere range of totally enclosed outdoor feeder busways goes up to 4000 for copper and 3000 for aluminum. Plug-in busways classified for 600-volt ac use predominantly remain in the range from 250 to 1000 amps, although plug-in systems rated up to 1500 amps may be obtained on special order, while lower-load users may obtain plug-in systems designed to meet smaller power requirements in the order of 250 amps down to 20.

This generalization is subject to an additional comment that some busways now are being rated on the basis of a 55-degree C rise above ambient temperatures when carrying full-load current under laboratory conditions, rather than



BUSWAY APPLICATIONS are advantageous in many types of structures. For example, upper sketch shows low-impedance feeder busways used to bring power from outside source to main interior switchgear of tall commercial building (c), then carrying power to upper-floor control centers (b and c). Lower sketch shows use of weatherproof feeder busway connecting outdoor transformer with interior switchgear of industrial plant (d); feeder busway then connecting with center-tap of plug-in system (e), while plug-in busways are used to carry power to machines, tools, welders and local panelboards (a and f).

being rated by the formerly-prevalent "rule of thumb" density measure of 1000 amps per sq in. Reasoning behind the newer theory is that current-carrying capacities can be affected considerably by heat dissipation from busbars, and that this in turn is influenced by bar insulation, ventilation, heat convection, conductance, spacing of bars or their relationship to bus supports and housing; these several factors suggesting that determination of ratings solely on the basis of cross-sectional areas is subject to debate.

In selecting busways, therefore, it is pertinent to check the rating method, since "nominal" ratings can vary by as much as 50% under this dual-rating situation.

Comparisons of weight likewise necessitate generalization, since "similar" ampere ratings must be related to such additional factors as number of bars in assemblies (2-, 3- or 4-wire systems, half or full neutrals, single or multiple bars per phase); whether bars are bare or insulated; whether enclosures are ventilated or enclosed; formulas by which amp ratings were determined; also ratios of barstock to enclosure metal and over-all weights of assemblies. For example, a 2-bar single-phase aluminum-bus enclosed system obviously will contain a far smaller weight-percentage of barstock than will a copper 4-wire full-neutral ventilated installation.

Again in generalities, therefore, it may be stated that busways considered collectively average approximately 20 lbs per ft per 1000 amps of current-carrying capacity, although this "mean" weight is subject to plus-or-minus fluctuations of 25% or more, depending on variables noted above. In this comparison, assemblies containing aluminum busbars may be from 5% to 30% lighter than copper assemblies with equal amp ratings.

Trends Affect Selections

Since over-all weight of a busway system in turn affects shipping costs, handling and installation labor, spacing of required supports and so on, the lighter poundage of aluminum assemblies is an influential consideration.

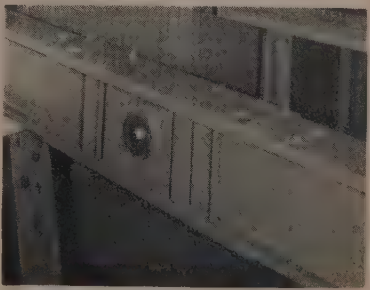
Another trend is towards more compact design, making it possible for smaller cross-section runs to be installed in tighter quarters.

Connection methods likewise are being simplified, as evidenced by fewer-bolt compression joints which not only speed installation routines but also permit checking and tightening of joint pressures between interleaved busbars from the outside of a busway while the system is either hot or dead. Keyed ends of busbars likewise are speeding assembly by promoting automatic alignment of these elements.

Previously-mentioned adjustable-length sections are other practical innovations, while simplification of hangers and brackets is reducing installation procedures to relatively simple sequences of positioning, connecting and supporting sections and components. Such contributing factors towards faster, easier assembly are abbreviating installation periods considerably; some contractors reporting time savings, compared with formerly-required schedules, 25% to 30%.

Improvements in design and construction likewise are obtaining higher short-circuit ratings, prevention of traveling arcs and lower voltage drops, while safety at plug-in points is being enhanced by safety slides over openings, polarized bus-connecting medium, interlocked switches and cubicle covers.

As to busway supporting devices, i addition to conventional clamp hangers, a new line of snap-on devices attach directly to busway flanges or, in some ventilated designs, directly into ventilation slots themselves. Such hook, snap and strap hangers may be placed at any desired location along busway runs, rather than at fixed positions as was necessary with some former assemblies. Other hangers are simply secured by inserting them between busway housing flanges from above, and spinning bolts into locking plates.



SOPHISTICATED DESIGN of feeder busways includes such products as epoxies and fiber glass in combination with totally-enclosed aluminum housings and fewer joint bolts, are small in cross section, with greatly reduced reactance.

SWITCHES

In modern electrical systems, a wide variety of switches is used for ON-OFF control of loads and for no-load circuit opening for isolation of equipment. Selection of the switch best suited to a specific task involves a number of considerations:

1. The electrical rating and characteristics of the switch must be proper for the circuit function to be performed. The switch must have the right number of poles and the proper voltage and current ratings for carrying the load impressed on it. If it is intended to interrupt current, it must have a suitable interrupting rating and must be suited to the nature of the load—resistive or reactive. For motor loads, hp rating must be considered. The switch must also be capable of withstanding the thermal and magnetic stresses of short circuits to which it might be subjected. This latter requirement demands careful correlation of short circuit available at the point of switch installation, short-circuit rating of the switch and the time-current characteristic of protective devices in the circuit.
2. Construction of the switch assembly must be suited to the usage that the switch will get. Switches used frequently must have sturdy make-up to assure long, trouble-free life. Such factors as contact mechanisms, arc suppressors, speed of "make" and "break" actions must be evaluated.
3. Auxiliary provisions—such as fuseholders or electrical operation of the contact mechanism—must be considered.
4. Enclosure requirements—type of housing for place of installation, interlock between enclosure cover and operating handle, provisions for locking switch in the OFF position—must be carefully weighed.

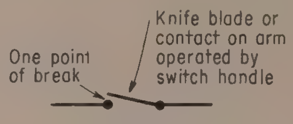
The foregoing considerations can only be made from a clear understanding of the characteristics of the many types and sizes of switching equipment available.

Basic construction and operating characteristics provide a means of classifying switches:

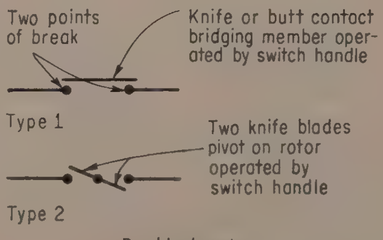
Number of Poles—In any switch, there are one or more line terminals and a corresponding number of load terminals. Each pair of line and load terminals is called a "pole." Therefore, the number of line terminals or load terminals will determine how a switch is to be classified as to number of poles. The number of poles corresponds to the number of conductor paths through the switch. There are 1-, 2-, 3-, 4-, and 5-pole switches in use in systems.

A "solid-neutral" switch is a switch with a number of poles (line terminals) equal to the number of wires carried through the switch, but with a solid conductor strap between a line terminal and the corresponding load terminal. The letters "SN" are used to designate "solid neutral." The grounded conductor of grounded systems is connected to these terminals. The switch contacts, then, open and close only the ungrounded conductors. The solid neutral strap is counted as a pole.

Contact Breaks—When opening a current path, a switch may break contact at one or two points in the current path. If it breaks at one point in each pole, it is called "single-break" type. If the switch breaks contact at two points in each current path, it is "double-break" type.



Single-break



Two points of break
Knife or butt contact bridging member operated by switch handle
Type 1
Two knife blades pivot on rotor operated by switch handle
Type 2

Double-break

Number of Throws—A switch may have one or more distinct closed-circuit positions. The vast majority of switches are single-throw type—i.e., a single closed circuit position. However, double-throw switches—with two different closed positions, providing either of two circuits through the switch—are commonly used to switch a load from one supply to another or to switch a supply from one load to another.

Type of Contact—The two common types of contacts used in switches are: knife-blade pressure contact; and high-pressure "butt" contact between fixed and movable contacts.

Method of Operation—Switches may have their contact mechanism actuated either by mechanical means or by electrical means. Where application of the hand to a switch handle provides all of the actuating force, this is mechanical operation. It is also mechanical operation when pressure acts on a pressure switch, or a cam on a limit switch, or liquid on a float switch. It is electrical operation when the hand or some automatic initiator closes the circuit to a solenoid or motor drive which then supplies the force to actuate the contacts.

NE Code

The National Electrical Code provides much guidance in the selection of switches. Various sections set forth ratings and other characteristics required for specific applications. And right at its beginning, the code gives specific definitions for types of switches referred to in the code, as follows:

GENERAL USE SWITCH: A switch intended for use in general distribution and branch circuits. It is rated in amperes and is capable of interrupting its rated current at its rated voltage.

MOTOR CIRCUIT SWITCH: A switch, rated in horsepower, capable of interrupting the maximum operating overload current of a motor of the same horsepower rating as the switch at the rated voltage.

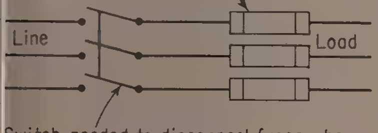
ISOLATING SWITCH: A switch intended for isolating an electric circuit from its source of power. It has no interrupting rating and is intended to be operated only after the circuit has been opened by some other means.

Section 110-9 of the code applies

switches (as well as to circuit reakers, fuses, relays, contactors) d says that "Devices intended to reak current shall have an interpting capacity sufficient for the oltage employed and for the curent which must be interrupted."

It is interesting to note that the ode does not require that disconecting means be provided for ranch-circuit conductors or for eeder conductors. The code does ave specific rules on disconnects or service entrances, appliances, otors and other "loads" but reuires only overcurrent protection, hich may be only fuses, for branch ircuits and feeders. However, Secion 240-18 requires that disconecting means be used on the line ide of cartridge fuses where they re accessible to other than qualified ersons to permit opening the ciruit before handling the fuses. This, in effect, requires the use of witches when such fuses are used o protect the circuits.

Cartridge fuses for feeder or branch-circuit protection

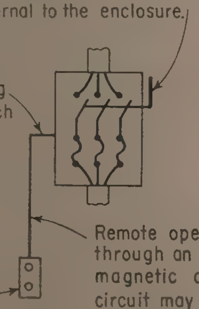


Switch needed to disconnect fuses when fuses are accessible to unqualified persons

Section 230-70 requires that a means be provided for disconnecting all conductors in a building from the service entrance conductors. This service disconnect may be a manually operated switch or circuit breaker, equipped with a handle or other suitable operating means.

Switch for service disconnect must be manually-operable by a direct-connected handle external to the enclosure.

To operating coil in switch



Pushbutton station outside service entrance room

Remote operation through an electro-magnetic control circuit may be used in addition to the required manual operation.

Note: Some local codes require both types of operation.

The service disconnecting means must have a rating not less than the load to be carried. In general, a service disconnect switch must not be rated less than 60 amps. For installations consisting of not more than two 2-wire circuits, a 30-amp minimum rating may be used. For single-family residences with an initial load of 10 kw or more (computed by code Section 220-4), the service switch must be rated not less than 100 amps.

One of the most important code requirements on service disconnecting means is that the device be "approved" for service equipment. According to the definition given in Article 100, "approved" means acceptable to the authority enforcing the code. But because Underwriters Labs has standards, conducts tests and furnishes label service covering design and construction of service equipment, inspectors invariably base their acceptance of a service switch on its UL label, attesting to its suitability. In this way, the inspector very wisely shares with UL the responsibility for the word "approved" and affords maximum safety for the application.

Article 380 of the code is entitled "Switches" and presents a number of major requirements directly affecting selection of switches, as follows:

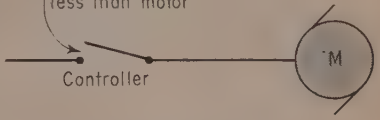
1. Switches must be of the externally operable type enclosed in metal boxes or cabinets, except pendent and surface type snap switches and knife switches mounted on an open-face switchboard or panelboard. And a switch in a wet location or outside of a building must be enclosed in a weatherproof enclosure or cabinet.

2. A circuit breaker operable directly by applying the hand to a lever or handle may serve as a switch provided it has the number of poles required for such switch.

3. Knife switches rated for more than 1200 amps at 250 volts or less and for more than 600 amps at 251 to 600 volts shall be used only as isolating switches and shall not be opened under load. To interrupt currents greater than 1200 amps up to 250 volts or 600 amps from 251 to 600 volts, a switch must be of a special design approved for such purpose. Knife switches of lower rating may be used as general-use switches and may be opened under load.

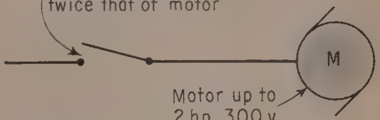
Article 430 of the code on "Motors and Motor Controllers" includes references to switches. A switch may be used as a motor controller if it has a horsepower rating not less than the horsepower of the motor. For a stationary motor rated 2 horsepower or less, and 300 volts or less, a general-use switch may be used as a motor controller if it has an ampere rating at least twice the full-load current rating of the motor.

Switch with hp rating not less than motor



Controller

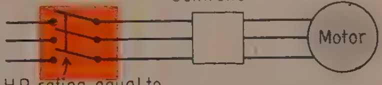
Amp-rated switch with rating twice that of motor



Motor up to 2 hp, 300 v

Section 430-101 requires a means of disconnecting both a motor and its controller from all ungrounded supply conductors. Section 430-109 says that this means must be a motor-circuit switch rated in horsepower or a circuit breaker, with certain exceptions. A general-use switch rated twice the motor full-load current may be used as the disconnect for motors rated up to 2 hp, to 300 volts. For stationary motors rated over 50 hp, the disconnect switch may be "a motor-circuit switch also rated in amperes, a general-use switch or an isolating switch."

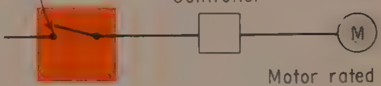
Controller



HP rating equal to that of motor

General-use switch rated twice motor amperes

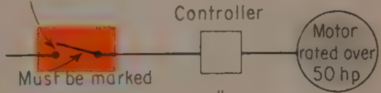
Controller



Motor rated 2hp or less

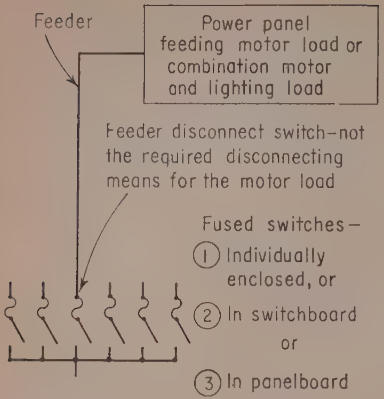
Isolating switch not capable of interrupting stalled-rotor current

Controller



Must be marked "Do not open under load"

Selecting Size of Feeder Disconnect Switch


Feeder
Power panel feeding motor load or combination motor and lighting load
Feeder disconnect switch–not the required disconnecting means for the motor load
Fused switches–
① Individually enclosed, or
② In switchboard or
③ In panelboard

Feeder disconnect switch is sized as follows:

A. MOTOR LOAD ONLY IN POWER PANEL: The switch must have an ampere rating at least equal to the required current rating of the feeder conductors. This current rating is equal to 125% of the full-load motor current of the largest motor fed from the power panel plus the sum of the full-load currents of the other motors fed from the panel. But the switch must accommodate the fuses which protect the feeder and these may have a maximum rating equal to the largest rating or setting of branch-circuit protective device in the power panel plus the sum of the motor currents of the other motors fed from the panel. This may require a larger switch. And if two or more motors fed from the panel must be started simultaneously, the starting current drain may be so heavy as to require increased size of feeder conductors, fuses and the disconnect switch.

B. MOTOR AND LIGHTING LOAD IN POWER PANEL: The switch must have an ampere rating at least equal to that required for the motor load (as described above) plus the amperes for the lighting and appliance load on the panel.

A switch which satisfies the code on rating for use as a motor controller may also provide the required disconnect means—the two functions being performed by the one switch—provided it opens all ungrounded conductors to the motor, is protected by an overcurrent device (which may be the branch-circuit protection or may be fuses in the switch itself) and is a manually operated air-break switch or an oil switch not rated over 600 volts or 100 amps.

Safety Switches

Safety switches are air-break switches which have their current-carrying parts enclosed in metal cases and which are manually operable by means of external handles. The word "safety" derives from the enclosed form which reduces the possibility of coming in contact with exposed energized parts of the switch assembly. Safety switches are referred to as "Enclosed Switches" in NEMA standards and in the standards and "Electrical Construction Materials List" of the Underwriters' Laboratories. This latter "List" of the UL contains data on enclosed switches as follows:

Enclosed switches with ampere rating are intended for general use. Enclosed switches with horsepower ratings in addition to ampere ratings are suitable for use in motor circuits as well as for general use.

Enclosed motor-circuit switches are intended for use only in motor circuits, and are marked "Motor-Circuit Switch."

Ratings of listed enclosed switches are limited to 3600 amp, 50 hp, 600 volts. When rated more than 1200 amp at 250 volts or less or more than 600 amp at more than 250 volts, enclosed switches may be intended and marked for isolating use only. Ratings of listed enclosed motor-circuit switches are limited to 50 hp, 600 volts.

Enclosed motor-circuit switches and enclosed switches with horsepower ratings are tested for interrupting capacity at rated voltage and at six times motor full-load running current for ac ratings and at four times motor full-load running current for dc ratings.

Some enclosed switches have dual horsepower ratings, the larger of which is based on the use of fuses with time delay appropriate for the starting characteristics of the motor. Switches with such horsepower ratings are marked to indicate this limitation and are tested at the larger of the two assigned hp ratings.

Most enclosed switches are also suitable for use as service switches and are marked "Suitable for Use as Service Equipment."

Enclosed switches are listed under the Label Service of UL and a label is attached to each switch.

NEMA Data

Safety switches are made in three different constructions based on the use made of switches and the places in which they will be installed. Basic NEMA data on these types of switches are as follows:

Heavy-duty switches, known as

Switch Enclosures

Type of enclosures used with enclosed switches are as follows:

Type 1—General Purpose

A general-purpose enclosure is intended primarily to prevent accidental contact with the enclosed apparatus. It is suitable for general-purpose application indoors where it is not exposed to unusual service conditions.

Type 3R—Raintight

A raintight enclosure is intended primarily to meet the requirements for raintight apparatus. It will also meet the requirements for drip-tight, splash-proof and moisture-resistant. It is suitable for general application outdoors where sleetproof construction is not required.

Type 4—Watertight

A watertight enclosure is designed to exclude water applied in the form of a hose stream. It is suitable for application where the apparatus may be subjected to a stream of water during cleaning operations and the like. It will also meet the requirements for drip-tight, splash-proof and moisture-resistant.

Type 7—Class I Hazardous Locations, Groups A, B, C or D—Air Break

These are enclosures for use in corresponding hazardous locations from the National Electrical Code. Circuit interruption is made in the air.

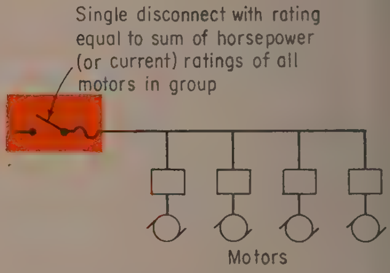
Type 9—Class II Hazardous Locations, Groups E, F or G

These are for use in corresponding hazardous locations.

Type 12—Industrial Use

An industrial-use enclosure is designed for use in those industries where it is desired to exclude such materials as dust, lint, fibers and flyings, oil seepage or coolant-seepage. It meets the requirements for dust-tight and oil-tight.

Disconnect Switch for Group of Motors
(NEC 430-112)


Single disconnect with rating equal to sum of horsepower (or current) ratings of all motors in group
Motors

Group of motors rated 600v or less:

1 Driving several parts of a single machine–or
2 The group is under protection of one set of short-circuit protection–or
3 The group of motors is in one room, within sight from the disconnect location

Disconnect for Motor Rated More Than 50 HP

Section 430-109 of the NEC makes a basic requirement that the disconnecting means for a motor and its controller be a motor-circuit switch rated in horsepower. For motors rated up to 50 hp, this is readily complied with, inasmuch as the UL lists motor circuit switches up to 50 hp, NEMA standards cover hp ratings of enclosed switches up to 50 hp and the manufacturers mark switches to conform. But for motors rated over 50 hp, the code does not require that the disconnect have a hp rating. It makes an exception to the basic rule and permits the use of ampere-rated switches or isolation switch, provided the switch has a carrying capacity of at least 115% of the nameplate current rating of the motor.

Example: Provide a disconnect for a 100-hp, 3-phase, 440-volt motor. Use a non-fusible switch inasmuch as short-circuit protection is provided at the supply end of the branch circuit.

The full-load running current of the motor is 123 amps. A suitable disconnect must have a continuous carrying capacity of 123 x 1.15 or 142 amps. This calls for a 200-amp, 3-pole switch rated for 480 volts. The switch may be a general-use switch or a current-and-hp marked motor-circuit switch or an isolation switch. A motor-circuit switch with the required current and voltage rating for this case would be marked for 50 hp, but the horsepower rating is of no concern.

The code requires that isolation switches for such applications be marked "Do Not Open Under Load."

If a fusible switch had to be provided for the above motor to provide disconnect and short-circuit protection, the size of the switch would be determined by the size and type of fuses used. Using a maximum fuse rating of 300% of motor current (Code Table 430-152 or 430-153) for standard NEC fuses, the application would call for 400-amp fuses in a 400-amp switch. This switch would certainly qualify as the motor disconnect. However, if time-delay fuses are used, a 200-amp switch would be large enough to take the time-delay fuses and could be used as the disconnect (because it is rated at 115% of motor current).

Type HD, are designed for safety under severe conditions of use—frequent operation of contacts and long periods of use. Their performance and continuity suit them to use in mass-production industries. Typical heavy-duty switches are rated from 30 amps up to 600 amps (30, 60, 100, 200, 400, 600) up to 600 volts ac. Enclosures shall be industrial types—Type 12 (with or without knockouts), 4, 7 or 9. Types 7 and 9 enclosures are for use with unfused switches.

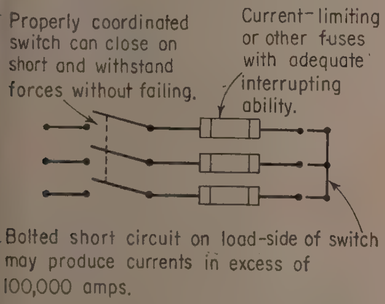
Normal-duty switches, known as Type ND, are designed for less severe conditions of application. They are widely used for industrial, institutional and commercial applications where service demands are not severe. Typical applications include motor branch-circuit disconnect and service entrance. They are rated 30, 60, 100, 200, 400, 600, 800 and 1200 amps, up to 600 volts ac. Enclosures shall be Type 1 or 3R.

Light-duty switches, known as Type LD, are designed for applications where switch operation will be infrequent. They are commonly used for service entrances in residences and for load and circuit disconnects in commercial, light industrial and farm-type buildings. Available ratings are 30, 60, 100 and 200 amps, up to 240 volts ac. Enclosures shall be Type 1 or 3R.

All three types of switches must be equipped with provisions for padlocking—to positively lock the switch in the OFF position.

Switches are rated in amperes in all cases. However, Types HD, ND and LD switches are also rated in horsepower. In the HD and ND types, switches rated 400 amps or less and 250 volts or less and switches rated 200 amps or less and above 250 volts are required by NEMA standards to be capable of interrupting motor locked-rotor current. Type HD switches must be able to interrupt locked-rotor current equal to ten times the full-load current ratings given in the NE Code for ac motors of corresponding hp rating. Types ND and LD switches must be able to interrupt current equal to six times full-load current of corresponding hp rating.

Short-Circuit Duty of Fused Switches


Properly coordinated switch can close on short and withstand forces without failing.
Current-limiting or other fuses with adequate interrupting ability.
Bolted short circuit on load-side of switch may produce currents in excess of 100,000 amps.

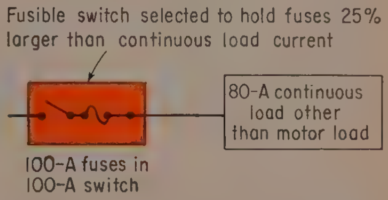
Very high short-circuit currents available in modern electrical systems demand careful attention to the ability of a switch to safely take the energy let-through by the fuses in the switch during fault interruption. This is also true of non-fusible switches in relation to short-circuit protective devices in their circuits. Ability to take potential short-circuit current may require use of heavy-duty switch instead of normal or light-duty switch.

HD and LD switches must be able to interrupt 150% of their current rating. ND switches must have the same interrupting ability for switches up to 1200 amps at 250 volts or less and up to 600 amps for voltages above 250.

Safety switches are made in non-fusible and fusible types. The non-fusible type is used for disconnect and control of feeder and branch circuits where overcurrent protection is provided in other devices. The fusible type is equipped with fuseholders to accommodate insertion of fuses in the ungrounded legs. Fused switches are used to provide disconnect and overload and short-circuit protection for feeders and branch circuits. Fusible switches take cartridge fuses from 30 amps up. Light duty switches are available for use with plug fuses up to 30 amps.

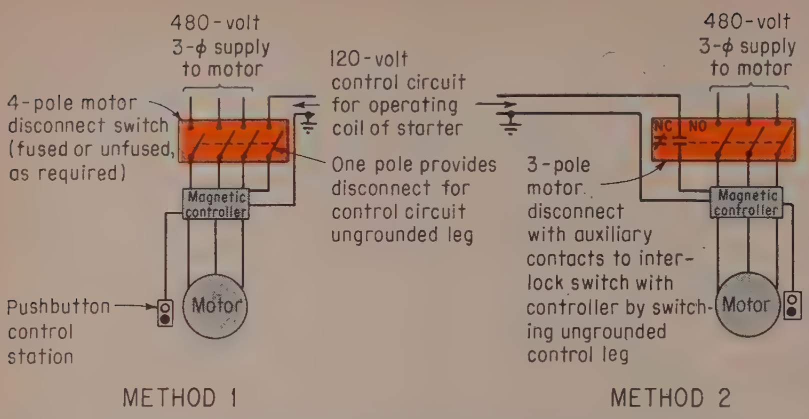
It is interesting to note that NEMA standards require that a fused enclosed switch be marked, as part of the electrical rating, "Continuous Load Current Not to Exceed 80% of the Rating of Fuses Employed in Other Than Motor Circuits." This derating takes into account the heating effect of the fuses on the switch and the lower operating point of the fuse due to

Switch for Continuous Load


Fusible switch selected to hold fuses 25% larger than continuous load current
80-A continuous load other than motor load
100-A fuses in 100-A switch

Because fuses are rated according to their ability to carry current continuously when placed in open air, on a bench, in a horizontal position, consideration must be made of the effect on fuses of heat accumulation due to their enclosed mountings in safety switches. To assure continuous opertion of loads—minimizing the chance of nuisance fuse blowing—fusible switches must be rated to accommodate fuses which are at least 25% higher in rating than load currents which will be flowing for several hours or longer. Another way of stating this application requirement is that the load current must not exceed 80% of the fuse rating.

Disconnect Means for Separate Control Power

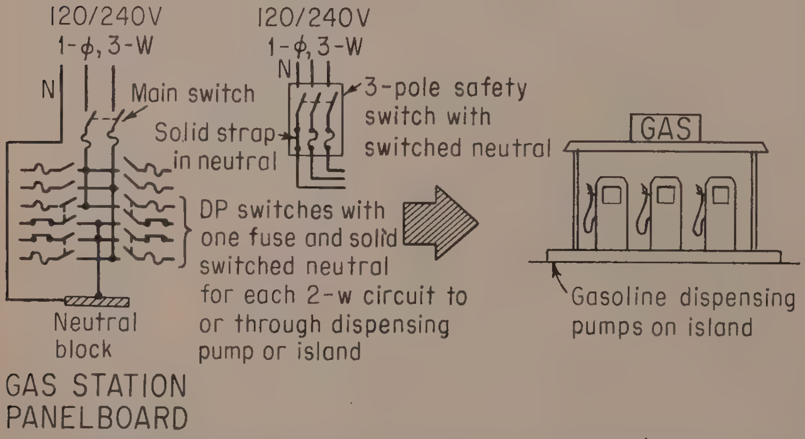


Section 430-74 of the NEC rules on disconnection of coil control circuits of magnetic motor starters says: "Control circuits shall be so arranged that they will be disconnected from all sources of supply when the disconnecting means is in the open position. The disconnecting means may consist of two separate devices, one of which disconnects the motor and the controller from the source of power supply for the motor, and the other, the control circuit from its power supply. Where the two separate devices are used, they should be located immediately adjacent one to the other. The above illustrations show two methods of providing for disconnect of separate control power without the use of additional switch device. The alternative to the above methods is to use a suitable switch in an enclosure, adjacent to the power disconnect.

METHOD 1 shows use of a power disconnect with one more pole than required for the power circuit. The extra pole then switches the control circuit, assuring complete absence of power on load side.

METHOD 2 shows the use of a power disconnect switch which contains auxiliary contacts (as a typical case, one normally-closed and one normally-open contact) to interlock the starter control circuit with the disconnect. The mechanical arrangement is such that when the handle of the disconnect switch is moved from the ON to the OFF position, the auxiliary contacts in the control circuit open to kill the control power and open the starter before the contacts in the power circuit of the switch actually open. Such interlocking puts the load-break task on the starter. To provide that feature the interlock can be used even when the control power is taken from the motor-controller line terminals.

Switched Neutral for Gas Stations



Section 514-5 (in Article 514 on Gasoline Dispensing and Service Stations) of the NEC makes a specific requirement on "Circuit Disconnects." It states: "Each circuit leading to or through a dispensing pump or island shall be provided with a switch or other acceptable means to disconnect simultaneously from the source of supply all conductors of the circuit, including the grounded neutral, if any." The above sketches show how this can be accomplished using either a gas-station type panelboard, which has its bussing arranged to permit hookup of standard solid-neutral circuits in addition to the switched-neutral circuits required, or using one or more enclosed safety switches which the manufacturers make available for direct use in switched neutral circuits. Another way of supplying such switched-neutral circuits is with circuit-breaker type panelboards for which there are standard accessory breaker units, which have a trip element in the ungrounded conductor and only a switching mechanism in the other pole of the common-trip breaker.

the fact that it is enclosed. Th nameplate rating of the fuse is i open air, in a horizontal positio

A fusible switch can take eithe standard NE Code fuses or time delay fuses—up to the rating of th switch. Because a given size o time-delay fuse can "hold" on th starting current of a motor large than that which could be used wit a standard fuse of the same rating fusible switches are given two h ratings—one for use with standar fuses, the other for use with time delay fuses. For example, a 30 amp, 2-pole, 240-volt ac switch i rated at 1½ hp for single-phas motor application using 30-am standard NEC fuses. But, usin 30-amp time-delay fuses, the sam switch is rated at 3 hp for single phase motor applications. Similarly a 200-amp, 3-pole, 240-volt ac switc is rated at 25 hp for 3-phase moto applications using standard fuse and at 50 hp using time-delay fuses

Non-fusible switches have hp ratings which correspond to the hp ratings of the same size and type of fusible switch using time-delay fuses. That is, a non-fusible switch has the higher of the two hp ratings assigned to the same switch in the fusible type.

Typical features of modern general-use switches include:

1. Quick-make quick-break operation of contacts to minimize contact wear due to arcs, better suiting the devices to interrupting inductive load currents and closing on high inrush currents. Types HD and ND switches have spring-loaded mechanisms to provide effective quick-make, quick-break contact operation. LD switches may have spring assist.

2. Visible blade construction to readily indicate position of switch contacts, whether ON or OFF, and to facilitate inspection and mainte-ance of parts.

3. High-pressure fuseholders to tightly clamp fuses in position, re ducing contact resistance and con sequent heat rise and providing longer, more reliable fuse life and lower switch maintenance.

4. Interlocking cover with handle to prevent opening the cover with the switch in the closed position, providing increased safety to personnel, with a means for authorized persons to defeat the interlock.

5. Padlocking provisions to positively lock the switch with contacts in the OFF position, for safe maintenance in electrical systems.

6. Double-break contacts to provide the better arc suppression of breaking contact at two points in each path of current flow, for cooler operation and extended contact life.

7. Arc quenchers or chutes for cooler, faster current interruption.

8. Removable switch interior to provide easy mounting of the enclosure and ready wire pulling.

9. Circuit-breaker contact mechanism in larger sizes of heavy-duty switches (200 amps, up) to provide efficient load interruption up to 12 times switch rating, using individual pole-springs and deionizing arc chutes and suited for use with current-limiting fuses at points of very high short-circuit duty.

10. Switch assembly reversible to place line terminals at top or bottom for straight-through wiring.

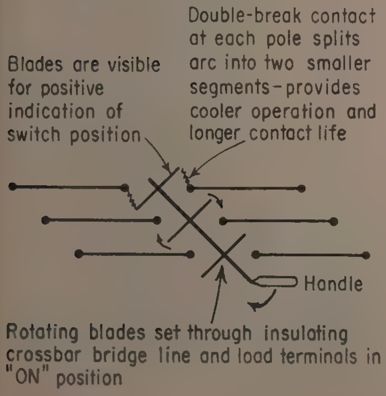
Although most applications of general-use switches call for single-throw types, the double-throw switch finds frequent application for manual transfer tasks. Heavy-duty and light-duty double-throw switches are made in fusible and non-fusible types for manual load transfer or for motor reversing.

Panelboard Switches

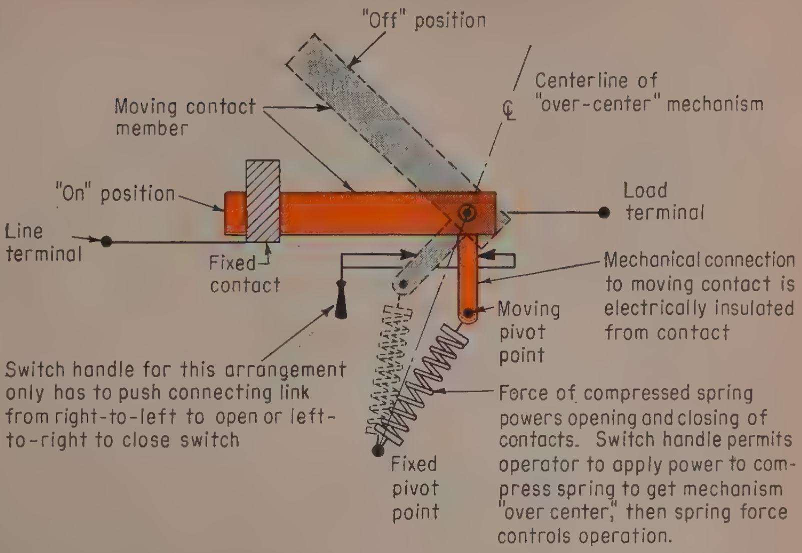
A wide variety of switches are made for use in switchboards, panelboards and motor control centers. Such switches are designed for group mounting, with their line terminals supplied from the busbars in the assembly. Their method of installation clearly differentiates them from safety switches, which are individually enclosed, although some panelboard type switches are available in individual enclosures.

Panelboard switches are always front operated due to their mounting. There are turnover pullout

Operation of Rotary Contact Assembly


Double-break contact at each pole splits arc into two smaller segments—provides cooler operation and longer contact life
Blades are visible for positive indication of switch position
Handle
Rotating blades set through insulating crossbar bridge line and load terminals in "ON" position

Basic Concept of Quick-Make Quick-Break


"Off" position
Centerline of "over-center" mechanism
℄
Moving contact member
"On" position
Load terminal
Line terminal
Fixed contact
Mechanical connection to moving contact is electrically insulated from contact
Moving pivot point
Switch handle for this arrangement only has to push connecting link from right-to-left to open or left-to-right to close switch
Force of compressed spring powers opening and closing of contacts. Switch handle permits operator to apply power to compress spring to get mechanism "over center," then spring force controls operation.
Fixed pivot point

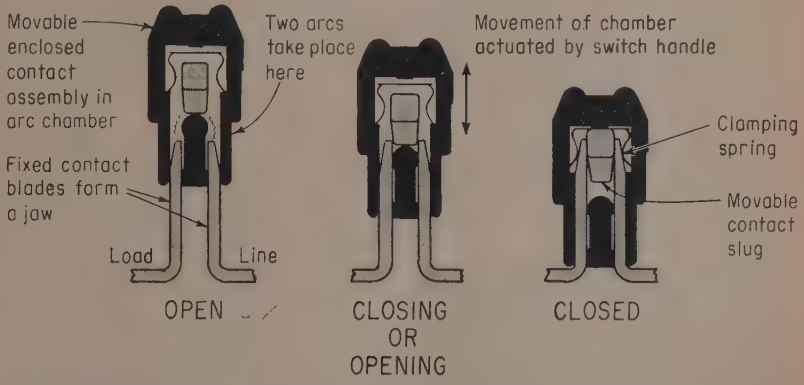
QUICK-MAKE QUICK-BREAK operation of switch contacts is accomplished by one or more springs in a wide variety of possible mechanical arrangements to perform the basic action indicated in this simple diagram. High spring pressure and low friction produce snap-action opening and closing, completely independent of handle once operation is initiated. Contact making or breaking cannot be "teased"; high-speed action cannot be retarded by handle. Handle is not fastened to contact operator. It serves only to "load" the spring mechanism and then to trip the mechanism.

In switches with "spring-assist" or "spring-accelerated" mechanisms, the operating handle is fastened to the contact operator and does all of the opening and closing action, but a spring over-center mechanism is added to supplement the force which the hand applies to the switch handle.

Some switches of the light-duty type have a mechanism for quick-break only in the larger size units (60-amp and above).

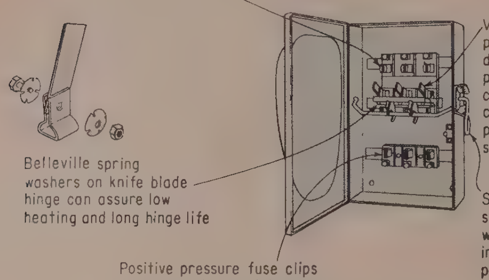
Quick-make quick-break mechanisms are usually placed inside the switch housing, in the gutter. Some switches, however, have the mechanism in the handle assembly on the outside of the switch enclosure, providing unobstructed gutters on both sides of the switch interior.

Double-Break Contacts in Enclosed Chamber
(Basic Single-Pole Action of one Type of Double Break)


Movable enclosed contact assembly in arc chamber
Two arcs take place here
Movement of chamber actuated by switch handle
Clamping spring
Fixed contact blades form a jaw
Movable contact slug
Load
Line
OPEN
CLOSING OR OPENING
CLOSED

1. Enclosed arc chamber reduces arc burning action on contacts by limiting air in the chamber during opening, snuffing out the arcing action.
2. Two points of current-interruption break opening arc energy into two arcs in series. This action extinguishes arc with reduced travel of contact assembly.
3. Magnetic fields around the series arcs are opposed to each other, forcing the arcs into longer paths and into the walls of the chamber, which transfers the heat and cools the arc, aiding extinguishing of the arcs.
4. Movement of a movable slug in the chamber provides wiping action of surfaces carrying current during ON position of the switch, and shape of the slug and fixed blades keeps arcing action at parting corners, away from normal carrying surfaces.
5. Assembly provides quick-make quick-break action through spring-pressure drive of handle and actuating mechanism which moves the enclosed head assembly.

Typical Features of Enclosed Knife Switch



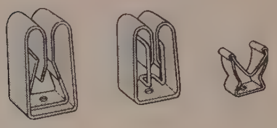
Switch jaws must be substantial to dissipate heat, spring-loaded over entire contact area and designed to keep arc damage from contact area

Visible blades positively reveal de-energized position and condition of contact surfaces, provides easy servicing

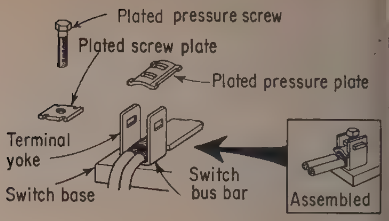
Belleville spring washers on knife blade hinge can assure low heating and long hinge life

Switch handle that stays with switch will give dependable indication of contact position.

Positive pressure fuse clips can assure low resistance and high conductivity, minimizing heat accumulations which cause fuse-blowing and even damage to switch



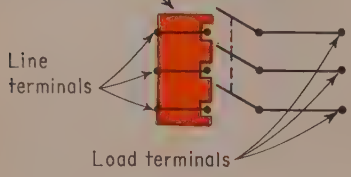
Lay-In Terminal Lugs for Switches



For larger sizes of conductors—MCM sizes—and for aluminum wires, lay-in type terminal lugs in switches offer advantages of speed and ease of terminal connections. Wires are simply laid in the empty yoke and then the screw, screw plate and pressure plate are assembled on the yoke and the terminal tightened. This eliminates difficult bending and training of stiff conductors in confined space of enclosure end gutter, which may be required with push-in type terminals.

Line Shield for Dead-Front "Off" Position

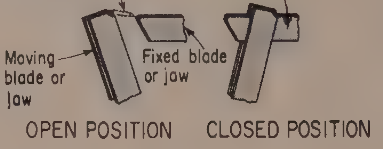
Insulating plate or insulating arc-chamber barrier protects against contact with line-side parts, making switch dead-front in "OFF" position for safe maintenance



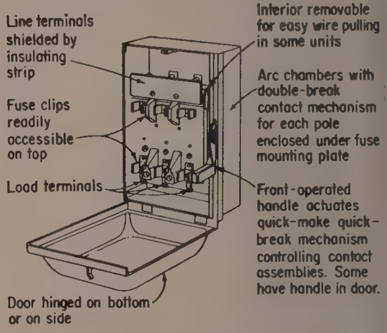
Knife Design Isolates Arc Burning

Tapered end of fixed member draws arcing action of current interruption to ends of members

Burning and beading due to arcs are only at tips, keeping normal current-carrying contact surfaces clean



Compact-Type Switch for Limited Space



Line terminals shielded by insulating strip

Fuse clips readily accessible on top

Load terminals

Door hinged on bottom or on side

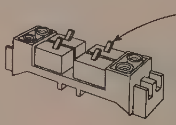
Interior removable for easy wire pulling in some units

Arc chambers with double-break contact mechanism for each pole enclosed under fuse mounting plate

Front-operated handle actuates quick-make quick-break mechanism controlling contact assemblies. Some have handle in door.

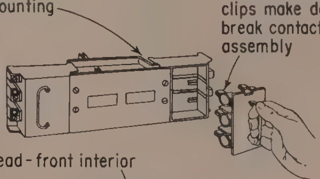
Types of Panelboard Switches

Snap switches in fuse-type panelboards.

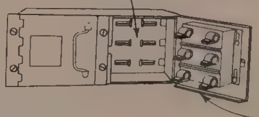


1-pole and 2-pole quick-make quick-break 30-amp tumbler switches for 120-v and 240-v branch circuits with plug fuses in lighting panelboards

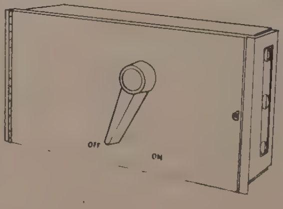
Pullout switches with fuses in pull cover, rated in hp and current up to 200 amps, for use in service and distribution panels or individually enclosed for service main or feeder, 2 or 3 poles, usually 240-volt light-duty applications.


Twin unit for panel mounting
Blades on fuse clips make double-break contact assembly

Hinged-door pull units with fuses on inside of door (shown here) or with only blades inside door and fuses in the box, rated in hp and current up to 600 amps, for use in power and distribution panelboards and switchboards, or individually enclosed for service or feeder, light-duty use.



Heavy-duty, industrial-type, hinged-door, quick-make quick-break switches with front-mounted, rotary-action handles, rated in hp and current up to 1200 amps, 600 volt, ac, for use in power and distribution panelboards and switchboards and in combination motor starters in control centers.



units, hinged-door pull-action units and rotary-handle hinged-door units—all incorporating their own fuses. There are also snap switches used. The turnover-pullout switches are generally confined to service equipment and lighting and appliance panels for residential and commercial use. Such pullout units are made up to 200 amps for 120/240-volt circuits and are current and dual-hp rated for standard or time delay fuses. There are also 3-phase pullouts, up to 600 volts. The pullout feature of such switches may be equivalent to locking "OFF."

The pull switches and rotary-handle switches of the hinged-door types are made in ratings up to 600 amps, 600 volts. These switches are widely used for switchboards, power panels and for motor control centers. They are for heavier duty application than the pullout type switches. And the rotary handle switches are of quick-make quick-break design for long, reliable operating life under heavy use.

Busway Switches

Fusible and non-fusible switches for use on plug-in busway systems are made available by the manufacturers of busway. Generally, these switches have electrical ratings and operating constructions similar to the hinged-door pull-action and rotary-handle switches used with panelboards. Busway switches are made with current and horsepower ratings. Typical plug-in units are made up to 600 amps. Fusible switch cubicles for protecting reductions in size of busway are made in higher ratings.

Bolted-Pressure Switch

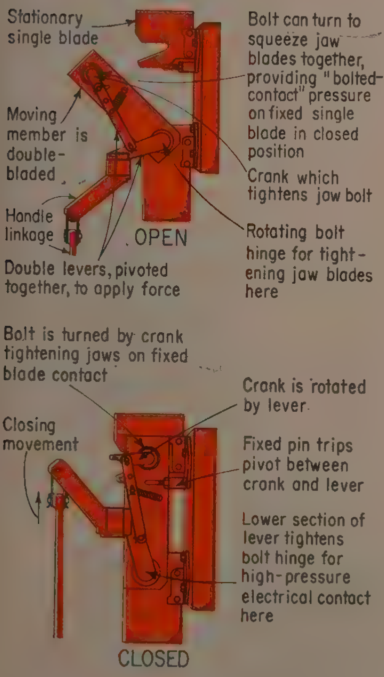
A wide range of types and sizes of switches is available for use in modern high-capacity feeder and service entrance applications. In the range from 200 amps to 1200 amps, up to 600 volts, service entrance and feeder applications can use heavy-duty, quick-make quick-break fusible safety switches. In the range from 1200 amps up to 6000 amps, either the bolted-pressure switch or the power circuit-breaker type load interrupter is used.

Many high-capacity secondary-voltage service entrances make use of bolted-pressure contact switches. Typical switches of this type are made in sizes from 1200 amps up. They are generally manually operated with external handles. Most common application is in a general-purpose, ventilated enclosure, either individually enclosed in an incoming line section or combined within a main secondary switchboard. Such a switch is generally used with high-capacity fuses of either the current-limiting or non-current limiting type, depending upon bus bracing and coordination requirements.

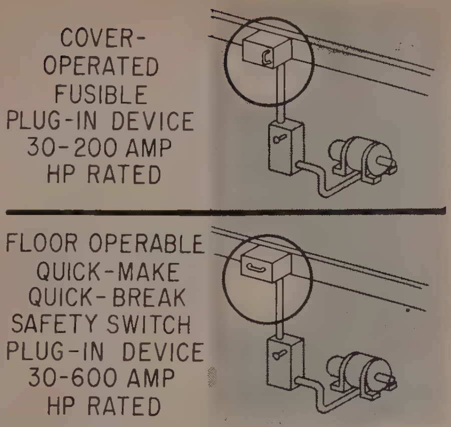
Modern bolted-pressure switches are rated for breaking load, withstanding let-through thermal and magnetic stresses during fuse operation on short circuit and for closing against a short circuit. Typical units are rated for load breaks up to 150% of the nameplate current rating, at 75% to 80% power factor. Design is such that after a large number of such rated load breaks, the switch is still capable of carrying full-load current continuously without dressing the contacts.

With proper fusing, the assembly is capable of fault clearance through the fuses. With the switch closed and fitted with high-interrupting-capacity fuses, faults well in excess of 100,000 rms amperes at 600 volts can be cleared promptly and safely without damage to equipment or personnel.

Action of Bolted-Pressure Switch


Stationary single blade
Bolt can turn to squeeze jaw blades together, providing "bolted-contact" pressure on fixed single blade in closed position
Moving member is double-bladed
Crank which tightens jaw bolt
Handle linkage
OPEN
Rotating bolt hinge for tightening jaw blades here
Double levers, pivoted together, to apply force
Bolt is turned by crank tightening jaws on fixed blade contact
Crank is rotated by lever
Closing movement
Fixed pin trips pivot between crank and lever
Lower section of lever tightens bolt hinge for high-pressure electrical contact here
CLOSED

Tap Switches for Plug-in Busway


COVER-OPERATED FUSIBLE PLUG-IN DEVICE 30-200 AMP HP RATED
FLOOR OPERABLE QUICK-MAKE QUICK-BREAK SAFETY SWITCH PLUG-IN DEVICE 30-600 AMP HP RATED

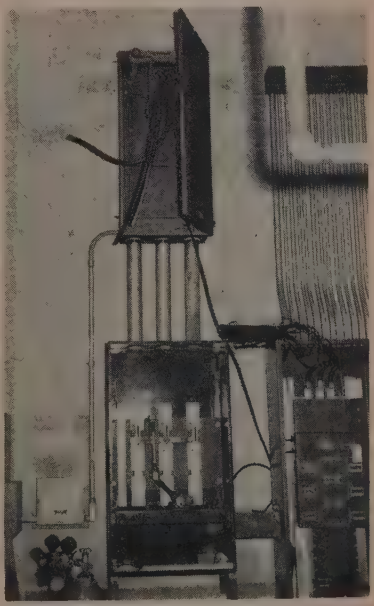
Switches suitable for operation by hook-stick provide ready accessibility to motor disconnect on busway, satisfying code requirements.

Hook-stick should provide ready opening and closing of switch from the floor.

Section 380-8 of the NEC requires that: "Switches and circuit breakers, so far as practicable, shall be readily accessible and shall be grouped." The code definition for "readily accessible" is "capable of being reached quickly, for operation, renewal or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc." From that, a switch used as a plug tap from busway is not "readily accessible."

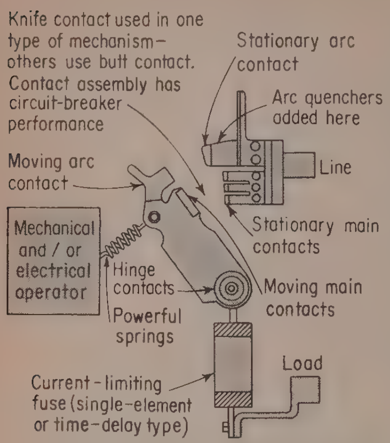
If the busway tap switch feeds down to a lighting or power panel, it could be said that the use of the switch on the busway is acceptable under the exceptions inferred by the phrase "so far as practicable" in Section 380-8. And this is supported by the fact that although the code requires fuses and other overcurrent devices to be readily accessible (Section 240-16), it makes an exception in the case of overcurrent protection in busway plug-in taps.

When a busway tap switch serves as the disconnect means for a motor, however, there seems to be no escaping the rigid rule of Section 430-107—"The disconnecting means (for a motor and its controller) shall be readily accessible." Various inspection groups and widely accepted practice recognize the use of a hook stick to operate the busway switch as making the switch "readily accessible."

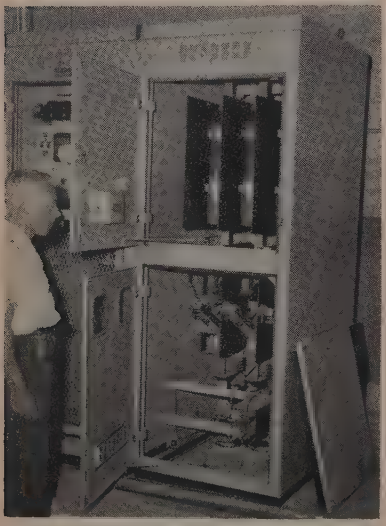


BOLTED PRESSURE SWITCH is used in typical application for service disconnect and overcurrent protection (when fuses are installed) for 1200-amp, 240-volt 3-phase service to a commercial building.

Fused Load-Interrupter Switches (Basic Concept for 600-volt Units)


Knife contact used in one type of mechanism—others use butt contact. Contact assembly has circuit-breaker performance
Stationary arc contact
Arc quenchers added here
Line
Moving arc contact
Mechanical and / or electrical operator
Stationary main contacts
Hinge contacts
Moving main contacts
Powerful springs
Load
Current-limiting fuse (single-element or time-delay type)

COMPOSITE RESUME OF AVAILABLE FEATURES: Used for control and protection on heavy-duty feeders and for service disconnect and protection (only if manually operable). Continuous current-carrying ratings up to 4000 amps (with fuses), up to 600 volts, 3-phase. Switch has load-break rating up to 12 times nominal current rating and is completely coordinated with fuses which provide time-delay protection against overloads and current-limitation to minimize let-through energy on ground and short faults up to 200,000 rms symmetrical amperes. Switch can close on and withstand thermal and magnetic stresses of such faults, with switch opening on single fuse blow to prevent single phasing. Stored-energy spring mechanisms for quick-make quick-break operation, with manual operation and remote electrical operation. Assembly mounted in separate enclosure, in switchboard or in draw-out switchgear housing for ready maintenance.



LOAD INTERRUPTER SWITCH is shown in bottom section of cubicle for use in conjunction with solid material power fuses, in top section, to provide disconnect and overcurrent protection for 4160-volt service to transformer in building.

Load-Interrupter Switch

Another type of high-capacity switch for use where currents are in the range of thousands of amperes is the fused interrupter. Fused interrupter switches are made for service entrance and feeder applications for systems under 600 volts. Such a switch is a fully coordinated combination of a circuit-breaker mechanism and current-limiting fuses. Characteristics of such a switch are as follows:

1. Increased safety and lower maintenance due to the quick-make quick-break operating mechanism which makes speed of operation independent of force applied by the operator.

2. Load-interrupting ability in the switch itself up to 12 times rated current and ability to safely close against short-circuit currents.

3. Suitability for use where short-circuit current is as high as 200,000 amps rms symmetrical, with fault interruption accomplished by the fuses.

4. Standard provision for electrical operation from a remote control position. Such remote operation is required by some local electrical codes for service entrance application.

Typical low-voltage fused interrupters are rated from 800 amps up to 4,000 amps, continuous. The switching mechanism is based on that used in low-voltage power circuit breakers—the so-called "large air breaker." The complete assembly—switch and fuses—is available in a free-standing general-purpose enclosure or for mounting in a dead-front switchboard.

The advantage of the fused interrupter lies in its ability to assure safe and reliable switch interruption of normal current and overload current up to the value of overload current at which the fuses provide automatic, instantaneous clearing of the fault. There is then no possibility of switch operation above the ability of the contacts to safely interrupt fault current. In the case of a switch with an interrupting ability equal to its continuous rating, there is hazard in operation of this switch on a low-level fault current which is above the switch interrupting rating, but is not high enough to open the fuses before someone could open the switch. Opening such a switch at a current above its interrupting rating could damage or even destroy the switch. In theory, such hazard obtains whenever the switch has an interrupting rating less than the current value at which the fuses operate instantaneously.

High-Voltage Switches

Switching for modern high-voltage electrical systems can be provided by a number of different equipment installations. For any particular case, selection of the best arrangement depends upon: the point of application—either for outside or inside distribution or as service equipment; the voltage; the type of distribution system—radial, loop, selective, network; conditions—accessibility, type of actual layout of the equipment; job atmosphere, use; future system expansion; and economic considerations.

Modern high-voltage distribution in the range from 2300 volts up to 15,000 volts makes use of several types of switches. These include:

1. Enclosed air-break load-interrupter switchgear with power fuses,

2. Oil-filled cutouts (fused or unfused), and

3. Oil-immersed disconnect switches.

Modern air load-interrupter switchgear in metal safety enclosures is finding even wider application in high-voltage distribution systems, in combination with modern power fuses. Such metal-enclosed fused load interrupters offer a fully effective alternative to use of power CBs, with substantial economies, in many primary voltage systems for commercial and industrial buildings. Typical applications for such switchgear parallel those of power CBs and include the following:

1. In switching centers—Switchgear is set up for control and protection of individual primary feeders to transformer load centers. Here an incoming service bay is switched to bussing from which the feeders are tapped through individual fused load interrupters.

2. In substation primaries—Load-interrupter switchgear is used for transformer switching and protection in the primary sides of substations.

3. In substation secondaries—Here the switchgear is used as a switching center closely coupled to a high-voltage transformer secondary.

4. In service entrances—This is a single-unit application of a switchgear bay for service entrance disconnect and protection in a primary supply line. In many applications, more than one such assembly is used for multiple supply circuits, often in combination with emergency automatic transfer.

Fused air load-interrupter switchgear, typically rated up to 2000 amps, can match the ratings and required performance capabilities of power circuit breakers for a large percentage of applications in which either might be used. The load-interrupter switchgear does not provide as quick reclosing after fault opening as a CB because fuses have to be replaced. And it does not offer differential-relay protection of transformers against internal faults. Both of these shortcomings, however, are not generally sufficiently important in most industrial and commercial systems to warrant the substantially higher cost of CB.

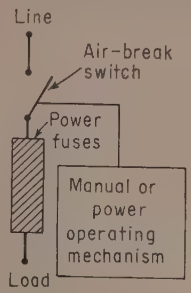
Oil-filled cutouts are also finding wide use as low-cost switching and, where desired, protective mechanisms for primary electrical systems. The oil-filled cutout is a completely enclosed, single-pole assembly with a fusible or non-fusible element immersed in the oil-filled housing and two terminals on the outside. The circuit is broken safely and rapidly by an internal mechanism made up of the fuse or a blade in its carrier and two contacts which the carrier bridges in the closed position. Operation is controlled at the end of the mechanism's shaft which comes out of the top of the unit.

With oil-filled cutouts, the switching of loads or breaking of fault current is confined within a sturdy grounded metal housing. By confining arc flame and current rupture forces, operation is safe and quiet. The cutouts are especially suited where there are explosive gases or inflammable dusts, where complete submersion is possible, where severe atmospheric conditions exist or where exposure of live electrical parts might be hazardous.

Oil-filled (sometimes called "oil-fuse") cutouts are made in three sizes based on continuous current rating—100, 200 and 300 amps. They are rated for use up to 15 kv. Such cutouts are made in three basic types: (1) pole-type cutout equipped with rubber-covered leads from the terminals—for use in open wiring applications; (2) pothead cutout equipped with an insulated cable from one terminal and a sleeve on the other terminal for connecting a lead-sheathed or rubber-covered cable from an underground circuit; (3) subway-type cutout with a sleeve for lead or rubber cable on each terminal.

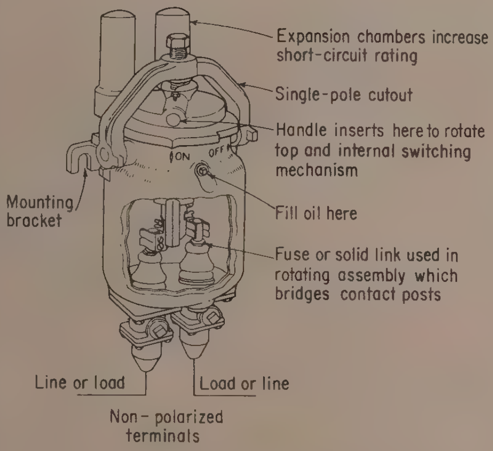
Common High-Voltage Load-Break Switches

Fused Load-Interrupter Switch



Switch ratings are 600, 1200 or 2000 amps, continuous current ratings, up to 15 kv.
Switch operating mechanism must provide that contact assembly can be closed and will be held closed by the operating mechanism against the maximum fault current that the line can deliver into a bolted short on the load terminals of the fuses, until the fault is cleared by the fuses. Switch must not be damaged in the closing or by the let-through energy. It should be noted that momentary and short-time fault ratings of such switches (such as 40,000 asymmetrical amps for 10 cycles and 25,000 symmetrical amps for 4 seconds, in the case of a 600-amp switch) apply only to the carrying ability of the contact assembly while held closed against the magnetic forces which would open the switch. In application, these ratings do not necessarily represent the safe closing rating, which is the maximum current the operating mechanism can close and hold against.

Oil-Filled Cutout


Expansion chambers increase short-circuit rating
Single-pole cutout
Handle inserts here to rotate top and internal switching mechanism
ON
OFF
Mounting bracket
Fill oil here
Fuse or solid link used in rotating assembly which bridges contact posts
Line or load
Load or line
Non-polarized terminals

Circuit Voltage Phase-to-phase	Maximum Current Rating-Amp	Interrupting Ratings Max. RMS-Amperes
	100	6,000
2,400	200	11,000
	300	11,000
	100	6,000
4,160	200	11,000
	300	11,000
	100	5,000
4,800	200	10,000
	300	10,000
7,200	100	3,750

For multi-phase circuits, two or three cutout units can be group mounted with a gang-operating mechanism for simultaneous operation. Load-breaking capability of the oil-filled cutout and its effective fault interruption suits it to many industrial and commercial applications for service equipment, for switching outdoor lighting for sports fields and shopping centers, and for transformer load centers. The oil-filled cutout is often the best device for a given application.

Oil-immersed disconnect switches are used for load control and for sectionalizing of primary-voltage underground distribution systems for large commercial and industrial layouts. Made for high power handling—such as 400 amps up to 34 kv and 1000 amps up to 600 volts—this type of switch can be located at transformer load center primaries or at other strategic points in cable circuits to provide a wide variety of sectionalizing arrangements—to provide alternate feeds for essential load circuits. Made for either manual or power operation, switches are available for as many as five switch positions and ground positions to ground the feeder or test-ground positions for grounding or testing.

Other types of load-break oil switches for use up to 15 kv provide either manual or electrically powered switching for all types of circuits. When electrical operation is used, the switch functions as a high-voltage magnetic contactor.

FUSES

A fuse is the simplest device used to open an electrical circuit when excessive current flows due to overload or short circuit. A fuse is a series circuit device which, when properly applied, will continuously conduct the current for which the fuse is rated but will internally open the circuit if the current flow through it should exceed the normal value. Based on performing this simple function, fuses are made in a wide variety of types and sizes—with a wide selection of continuous current ratings, differing abilities to interrupt fault currents, various speeds of operation for either quick opening or time-delay opening, different internal and external constructions and both low- and high-voltage ratings.

The operating element of a fuse is the internal link assembly which will respond to the I^2R heat power generated by the current flow through the fuse. The continuous current rating of the fuse is that value of current up to and including which the fuse will conduct without opening. NEMA Standards set forth conditions under which fuses are to be tested to determine their current rating, which is the designated rms ac or the dc current which the fuse will carry continuously.

Fuses are tested at a constant current on a 60-cycle circuit. They are tested in the open, mounted in a horizontal position on a bench or board—either in a single-pole fuseholder for fuses up to 600 amps or connected to busbars for larger fuses. In this test, the fuse must be capable of carrying 110% of rated current indefinitely without any damage to the assembly. Because ratings are checked in the open, consideration must be given to effective derating of fuses when they are enclosed under conditions of heat accumulation. It is common to take the rating of a fuse as 100% of rated current value when enclosed by a switch or panel housing. But due to the heat generated by many fuses, the continuous load on a fused switch should be held to 80% of the rating of the fuses.

A first breakdown of fuse types can be made on the basis of general construction. There is the cartridge fuse and the plug fuse. Both protect a circuit in the same way, by opening its current-responsive element when an overcurrent or short-circuit current passes through it. Each type is available with various characteristics. And although there are applications where either cartridge or plug fuses may be used, each type has certain exclusive areas of use.

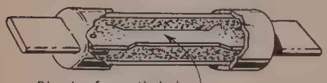
Cartridge Fuses

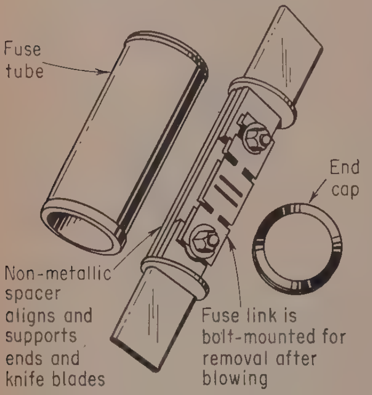
A cartridge fuse is a fuse consisting of a current-responsive element inside a fuse tube with terminals on both ends. On the basis of operating characteristics, cartridge fuses may be divided into the following categories:

1. Single-element fuses have a current-responsive element of a single fusing characteristic. These are the fuses usually referred to as "standard NEC (National Electrical Code) fuses." They are available in two forms—

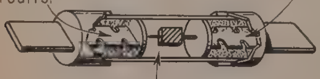
A. Non-renewable fuse, the so-called "one-time" fuse, cannot be restored for service after it blows and must be discarded and replaced

Basic Types of Fuses (Up to 600 Volts)

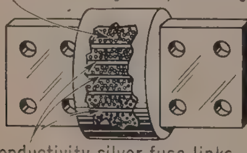

Single fuse link in arc-quenching filler clears overload or short


Fuse tube
End cap
Non-metallic spacer aligns and supports ends and knife blades
Fuse link is bolt-mounted for removal after blowing

Standard or current-limiting, large, high-conductivity links in arc-quenching filler pass overloads but open quickly on short circuits.


Time-delay melting unit clears overloads only.

Sand filler for cooling and quenching arc


High-conductivity silver fuse links carry load current with very low heating of fuse but open quickly on overload or short and provide limiting of current below value which is available.

ONE-TIME FUSE:
Rated for 250 or 600 volts, up to 600 amps. Used for resistive type loads, without inrush or surge currents, or where size of fuse masks levels of inrush. Offers effective and economical use on steady-state loading, when maximum potential fault currents are not in excess of 10,000 amps.

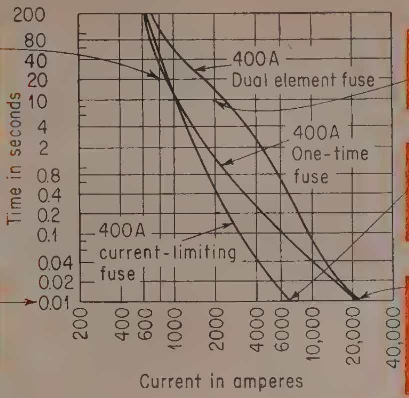
RENEWABLE FUSE:
Generally similar to one-time fuses, with economy of link renewal instead of complete replacement after blowing and with availability of longer time delays through more detailed link design. Suited to use with resistive and motor loads, particularly in industrial areas or where operating conditions promote high occurrence of shorts and overloads. Time-delay ratings suit fuses to motor feeders and subfeeders where individual motor starting currents can take advantage of load diversity in conjunction with the limited time delay.

DUAL-ELEMENT FUSE:
Same continuous current and voltage ratings as one-time fuses, but with interrupting ratings up to 100,000 amps and, when the fuse contains current-limiting short-circuit links, up to 200,000 amps. Suited to protection of any and all types of loads, with very long time delay for motor inrush.

CURRENT-LIMITING FUSE:
Rated for 250 or 600 volts. Fuses rated up to 600 amps are made for use with standard or special (rejecting type) knife-blade or ferrule clips. Fuses rated from 601 to 6000 amps are for stud mounting. All have fast, current-limiting action, minimizing let-through.

HIGH-CAPACITY FUSE:
Rated for 600 volts or less, from 601 to 6000 amps. Suited for heavy-duty mains and feeders. Not designated current-limiting, but has current limitation on high value faults. Also has time-delay to hold on overcurrents. Has same IC as current-limiting fuses—200,000 amps.

Comparison of Types of Fuses by Operating Characteristics



All three types of fuse open in less than 10 minutes at 200% of rated load, as required by standards.

Approximate point of current limitation at this speed or faster for clearing time of fuse.

Dual-element fuse holds for well over 10 seconds at 500% of load (2000 amps), as required.

Current limiting fuse becomes current limiting at 7000 amps — well within the required threshold ratio of 30.

Both other fuses become current limiting at about 25,000 amps — a threshold ratio of over 60 and a fault in excess of the 20,000-amp IC of the one time fuse.

by another fuse. Such fuses are available for either 250 volts or 600 volts, up to 600 amps. Ordinary one-time fuses have comparatively little time delay in their operation. The fuse will carry 110% of its rated current continuously in open air and about 100% of rated current installed in an enclosure.

At currents above 110% rated value, the fuse will blow. It will blow after some time delay on low overloads and will blow quickly on shorts or high overloads. Fuses rated up to 60 amps must blow in not more than 60 minutes when 135% (125% when enclosed) of rated current flows; and on 200% (190% when enclosed) rated current, fuses rated to 30 amps must blow in no more than two minutes and fuses rated 31-60 amps must blow in no more than four minutes. Fuses from 61 to 600 amps must not hold for more than two hours on 135% of rated current. On 200% current, such fuses must blow in maximum times as follows: 61 to 100 amps, 6 minutes; 101 to 200 amps, 8 minutes; 201 to 400 amps, 10 minutes; and 401 to 600 amps, 12 minutes.

The foregoing values establish maximum allowable time delays according to NEMA Standards. Time delays of ordinary one-time fuses fall far short of these values. As a result, they are generally susceptible to blowing on harmless overloads and motor starting currents. They are suitable for use on circuits with little chance of operating overload, such as lighting circuits, where the fuse guards against grounds and shorts. When used on motor circuits for branch-circuit protection, they must take full advantage of the code permission to use fuses rated up to three or four time motor running current. And when used in switches in other than motor circuits for continuous operation, they must be derated because of the relatively high heat they develop, which will derate the fuse and may damage the switches. Standard practice with fused safety switches limits the load to 80% of the fuse current rating.

The standard short-circuit interrupting rating of these fuses is 10,000 amps. This limits the use of such fuses to circuits where the available short-circuit current does not exceed that value.

B. Renewable fuse is one which may be readily restored for service after operation by replacement of the renewal element, the current-responsive single element which provides the protection. These fuses are electrically similar to the one-time fuses and are available in the same current and voltage ranges. They are subject to the same maximum time delays as the one-time fuses at 135% and 200% of rated current, but through more detailed design of the fuse link and terminal assembly, renewable fuses are commonly made with longer time delay than standard one-time fuses in the range up to and above 200% rated current.

Renewable fuses, although they cost more at first than one-time fuses, offer the economies of repeated renewal of the fusible link, which is much less expensive than replacing the entire fuse. This is in addition to the advantages of generally longer time delay, more durable construction of the assembly and flexibility of rating changes for electrical expansion or alterations by changing fuse links within a classification (such as a 100-amp link for a 70-amp link, in the 61- to 100-amp classification, provided that the change affords proper protection for the application and that the cartridge label is marked with the new current rating).

The longer time delay of many renewable fuses permits use of fuses for short-circuit protection rated less than the maximum permissible ratings of NE Code Tables 430-152 and 430-153. For example, the code says a fuse rated up to 300% of motor current may be used for short-circuit protection of a branch circuit to a squirrel-cage motor with full-voltage starting. And using ordinary one-time fuses, such a large rating of fuse would generally have to be used to prevent blowing on starting current inrush. But a renewable fuse with proper time delay would only have to be rated, say, 225% of motor full load current to prevent blowing on starting current.

By making possible the use of a lower fuse rating, the renewable fuse might also permit the use of a smaller switch than would be necessary to accommodate the required size of standard one-time fuses. For instance, a 3-phase, 15-hp, squirrel-cage, 220-volt motor draws 40 amps full-load running current. One-time fuses used with this motor would have to be three times 40 or 120 amps, calling for 125-amp fuses in a 200-amp switch. But time-delay renewable fuses rated at 225% of motor current would only have to be 2.25 times 40 or 90 amps, calling for 90- or 100-amp fuses in a 100-amp switch. The code permits such use in Section 430-56.

Of course, there is no simple guide to the most efficient use of fuses for short-circuit protection of motor circuits. The NE Code offers some data on the maximum allowable sizing of standard NEC fuses for use with various types of motors, with varying starting current demands. Each specific application, however, must take into account: the type of motor—squirrel-cage, single-phase, wound-rotor, synchronous, dc; the design characteristics of the motor—high-, normal- or low-starting current; the torque requirements of the driven load; the thermal damage curve of the motor—time vs overload up to stalled rotor; and the continuous-current rating and time-delay characteristics of the particular type of fuses to be used. Effective application is the result of step-by-step analysis of all factors.

2. **Dual-element fuse** is a fuse having current-responsive elements of two different fusing characteristics in series in a single cartridge. One of the elements provides extended time-delay operation on overloads, and the other element functions to clear short-circuit currents.

These fuses have a much greater time delay than single-element time-delay fuses They are made to blow at 135% and 200% of rated current within the maximum limits described previously for one-time fuses. But the dual-element fuse has delay right up close to the maximum delay permittted, whereas the one-time and renewable fuses have time delays which are far from the maximum limits. For instance, a typical 30-amp, 250-volt dual-element fuse has a delay of 111 seconds before it operates with 200% of rated current flowing through it, while a typical 30-amp, 250-volt time-delay renewable fuse has a delay of only 18 seconds with 200% of current flowing through it.

In addition to the maximum time delays set by standards for 135% and 200% of rated current, dual-element fuses are required to have a minimum time delay of ten seconds before operating when 500% of rated current flows through them. This applies to all dual-element fuses up to 600 amps and produces a marked difference between dual-element fuses and time-delay one-time or renewable fuses. For instance, a typical dual-element fuse has a delay of 12.8 seconds at 500% load, whereas the same size single-element fuse has a delay of only 0.7 seconds.

The very long time delay of dual-element fuses enables them to handle much higher motor starting currents, without blowing, than even the time-lag single-element fuses. Thus they represent a further extension of the application possibilities for reduced-size fusing described for renewable fuses. Instead of using fuses rated up to 300% of motor full-load current rating to provide short-circuit protection of the branch circuit without blowing of the fuse, the designer can select fuses with continuous current rating of 100 to 125% of motor current, for many installations. Again, in very many cases, this will permit use of smaller switches than would be required for accommodating standard fuses. And when the rating does not exceed 125% of motor current, the same fuses may simultaneously provide the required running overload protection for motor and controller, in addition to short-circuit protection.

Although these fuses are particularly applicable to motor branch circuits and feeders, they are also ideally suited to all types of circuits for power loads, mixed lighting and power loads and for lighting loads alone.

Dual-element fuses are available with high interrupting capabilities, up to 100,000 amps with some typical fuses. And dual-element fuses offer much cooler operation—inherently low-resistance construction for lower I^2R losses in the fuse assembly, providing better loading for more efficient use of the fuses in switch and panelboard enclosures, with cooler operation to prevent heat damage to switches or other equipment and to minimize nuisance blowing of fuses due to accumulated heat.

3. **Current-limiting fuse** is a fuse which safely interrupts all available current within its interrupting rating and, within its current-limiting range, limits the clearing time at rated voltage to an interval equal to or less than the first major or symmetrical current loop duration and also limits peak let-through current to a value less than the peak current that would be possible with the fuse replaced by a solid conductor of the same impedance. A clear understanding of the nature of operation of current-limiting fuses is based on the following considerations:

A. Every fuse is designed to interrupt the current flowing through it when the value of current exceeds the continuous rating of the fuse. For light overloads, the fuse will have some time-delay depending upon its design. On heavy overloads, the fuse will open faster than on light overloads. And on short circuits, the fuse will open even faster. The higher the current, the faster the fuse opens. This is due to the fact that the fuse is responding to heat energy which is equal to I^2R times the time that current flows. As the current increases, I^2R value increases quickly and the time required to produce the energy to melt the link decreases.

B. If a value of 60-cycle short-circuit current within the interrupting rating of the fuse causes the fuse to open in less than 1/120th of a second, the current wave has not gone through one complete half-cycle loop. As a result, the fault current has not reached the rms value which it would reach if just one-half cycle were completed.

It is important to note that the rms value of any alternating current is equivalent to the dc current which would produce the same heating effect. Therefore, starting from zero, an ac wave reaches its rms when the first half cycle is complete. Each succeeding half cycle does not increase the rms value but simply represents the same rms value. Any fuse then that opens before a half cycle of current flows has actually reduced or limited the current. But the definition given above states that a current-limiting fuse must also limit the peak value of the current it passes before opening to a value less than the peak value normally obtained in the current wave which would flow if there were not a fuse to open the current.

The two requirements for current limitation are based on total clearing time in the operation of the fuse. Clearing time is the total time measured from the beginning of the specified overcurrent condition until the interruption of the circuit, at rated voltage. Clearing time is the sum of two components: melting time and arcing time. Melting time is the time required for the current to melt the heat-sensitive element. Arcing time is the time elapsing from the melting of the element to the final interruption of the circuit.

Under conditions of current limitation, total clearing time produces a triangular wave. As the short-circuit current wave starts from zero to increase to its peak value, melting occurs before the wave can reach the peak. The current then decreases as arcing takes place and is snuffed out in the fuse tube. From start of the short to the condition of open fuse, the time is less than 1/120th of a second. And the time from start of the short to the end of the melting time when the current starts to decrease is less than ¼ of a cycle, so that the peak of the short-circuit current wave was never reached.

C. Any fuse which can produce the above action within its operating range is actually a current-limiting fuse. As a result, standard one-time, renewable and dual-element fuses, which can produce such current-limitation, may be considered to be current-limiting fuses. But modern practice and usage of the term has reserved the term “current-limiting” for fuses specially designed to have a very high order of current limitation as described and high interrupting capabilities. Such fuses are made in sizes up to 6000 amps, rated at 600 volts but suitable for use at lower voltages. Basic NEMA Standards data on such fuses are as follows:

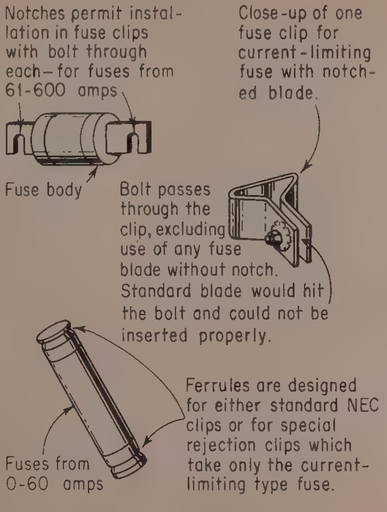
Class J Fuses—current-limiting fuses with interrupting rating of 200,000 rms amps, 60 cycles, in classifications of 0-30, 31-60, 61-100, 101-200, 201-400 and 401-600 amps, with maximum opening times at 135% of rating and 200% of rating as described previously under “One-Time Fuses.” But specific characteristics on current limiting must satisfy this table—

Threshold Ratio and Peak Let-Through
At 100,000 Amps Symmetrical rms Available Current
600 Volts, 60 Cycles and Less Than 15% PF

Cartridge Size, Amperes	Maximum Threshold Ratio	Maximum Peak Let-thru Current, Amperes
0-30	30	8000
31-60	30	10000
61-100	30	14000
101-200	30	20000
201-400	30	30000
401-600	30	45000

The table shows that Class J fuses become current-limiting at currents which are not more than 30 times the particular continuous current rating of the fuse. Threshold ratio is defined as, “. . . the threshold current divided by the fuse current rating.” The “threshold current” is the symmetrical rms available current at the threshold of the current-limiting range, where melting of the current-responsive element has occurred at approximately 90 degrees on the symmetrical current wave and total clearing time is less than one-half cycle at rated voltage, rated frequency, and with a circuit power factor of less than 15%. Peak let-through current is the maximum instantaneous current through the fuse during the total clearing time. Current limitation is illustrated on the following pages.

Non-Interchangeability for Current-Limiting Fuses


Notches permit installation in fuse clips with bolt through each—for fuses from 61-600 amps
Close-up of one fuse clip for current-limiting fuse with notched blade.
Fuse body
Bolt passes through the clip, excluding use of any fuse blade without notch. Standard blade would hit the bolt and could not be inserted properly.
Ferrules are designed for either standard NEC clips or for special rejection clips which take only the current-limiting type fuse.
Fuses from 0-60 amps

Class J fuses (current-limiting fuses rated up to 600 amps) are available with special ferrules (0 to 60 amps) or special blades (61 to 600 amps) to permit their ready insertion in special rejection fuseholders which will not accept standard NEC fuses (Class H—not current-limiting). But such Class J ferrules or blades can be inserted in standard NEC fuseholders. When equipment is used in conjunction with current-limiting fuses, with busbars or other parts braced and strengthened in accordance with fuse let-through short-circuit current, the use of these special rejection clips prevents the replacement of the current-limiting fuses with non-current-limiting fuses which might not limit the let-through current and, therefore, would not constitute adequate protection for the equipment to be protected. This potential hazard has been recognized by the NEC in Section 240-23 (b)—“Fuseholders for current-limiting fuses shall not permit insertion of fuses which are not current limiting.”

Another factor for which maximum limits are set is the “clearing I^2t,” which is a measure of the let-through energy, in terms of current and time, of the fuse during the total clearing time.

Class L Fuses—current-limiting fuses with interrupting rating of 200,000 rms amps, 60 cycles, in classifications of 601-800, 801-1200, 1201-1600, 1601-2000, 2001-3000, 3001-4000, 4001-6000, with maximum opening time of 240 minutes at 150% of rating. Other time-current characteristics are generally similar to those of Class J.

4. High-capacity fuses are one-time fuses in the range from 601-6000 amps, 600 volts, with interrupting rating of 200,000 amps and maximum opening time of 240 minutes at 150% of rating. They are not specifically designed to meet standard requirements for current-limitation, but they do possess some current-limiting ability in certain sizes under certain conditions.

5. Dual-element, current-limiting fuses combine the characteristics of long time delay of the dual-element fuse in the overload range up to and even above 500% of rating and the characteristics of Class J current-limiting fuse in the short-circuit operation. Such fuses are available up to 600 amps, 600 volts, with interrupting ratings up to 200,000 rms symmetrical amps.

These fuses offer the application advantages of the two types of fuses. They are particularly effective where their time delay suits motor requirements and their speed of operation provides for selective coordination with other line-side short-circuit device. Their current limitation also provides for bussing motor control centers and panelboards for withstanding lower short-circuit stresses due to reduction of let-through energy.

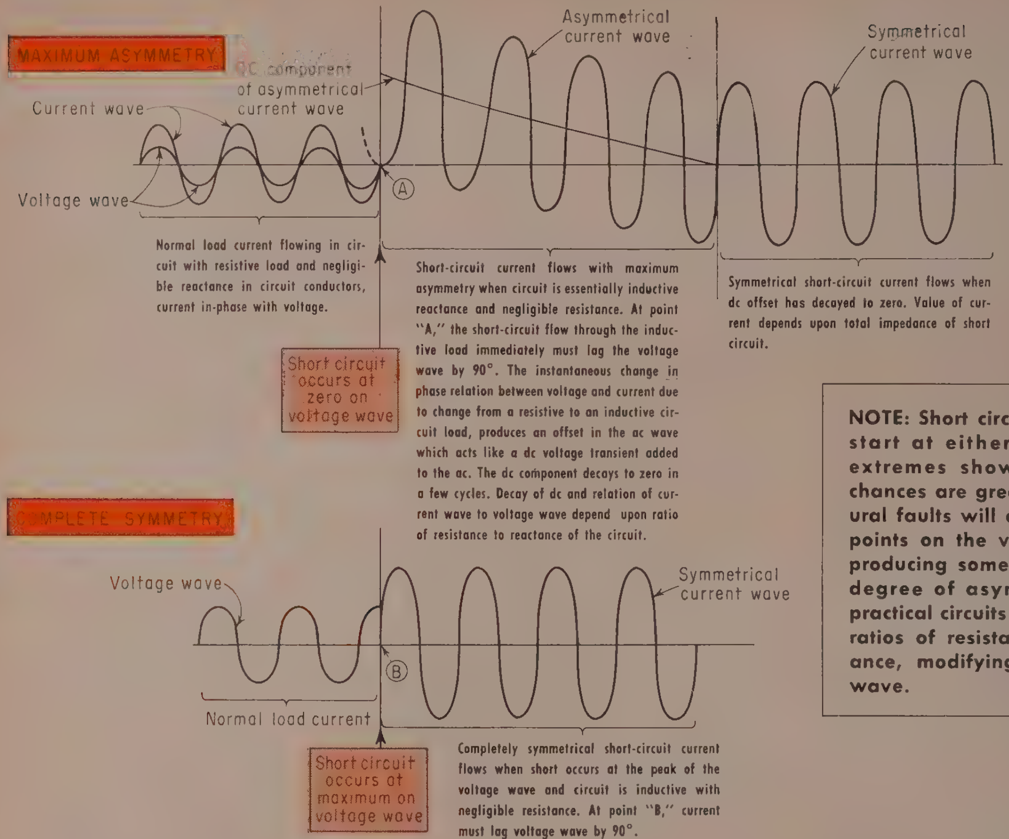
Plug Fuses

Plug fuses are screw-in type fuses. They have a screw-in base for ready insertion in and removal from suitable plug fuse holders. They are made in various current ratings up to 30 amps and are available in two types: with standard one-time, single-element fusing member; or with time-delay, dual-element construction. The time delay type has the same application advantages as described previously for cartridge type dual-element fuses. The single-element plug fuse is suitable for use where motor starting currents or other inrush current surges are not a problem. Both types are commonly used in panelboards, with or without snap switch control in conjunction with each plug-fuse circuit.

Plug fuses must not be used in circuits of more than 125 volts between conductors, but they may be used in grounded neutral systems where the voltage is not over 150 volts between any ungrounded conductor and ground.

Tamper-resisting, non-interchangeable plug fuses, known as Type S fuses, are designed for use in a Type S holder or in a standard holder with an adapter to prevent replacing of fuses in the range from 0 to 15 amps with fuses rated from 16 to 30 amps.

A—Basic Conditions of Short-Circuit Occurrence


MAXIMUM ASYMMETRY
DC component of asymmetrical current wave
Current wave
Voltage wave
Asymmetrical current wave
Symmetrical current wave
Ⓐ
Short circuit occurs at zero on voltage wave
COMPLETE SYMMETRY
Voltage wave
Symmetrical current wave
Ⓑ
Normal load current
Short circuit occurs at maximum on voltage wave

Normal load current flowing in circuit with resistive load and negligible reactance in circuit conductors, current in-phase with voltage.

Short-circuit current flows with maximum asymmetry when circuit is essentially inductive reactance and negligible resistance. At point "A," the short-circuit flow through the inductive load immediately must lag the voltage wave by 90°. The instantaneous change in phase relation between voltage and current due to change from a resistive to an inductive circuit load, produces an offset in the ac wave which acts like a dc voltage transient added to the ac. The dc component decays to zero in a few cycles. Decay of dc and relation of current wave to voltage wave depend upon ratio of resistance to reactance of the circuit.

Symmetrical short-circuit current flows when dc offset has decayed to zero. Value of current depends upon total impedance of short circuit.

Completely symmetrical short-circuit current flows when short occurs at the peak of the voltage wave and circuit is inductive with negligible resistance. At point "B," current must lag voltage wave by 90°.

NOTE: Short circuit faults can start at either of the two extremes shown here. But chances are greater that natural faults will occur at other points on the voltage wave, producing some intermediate degree of asymmetry. And practical circuits have varying ratios of resistance to reactance, modifying the current wave.

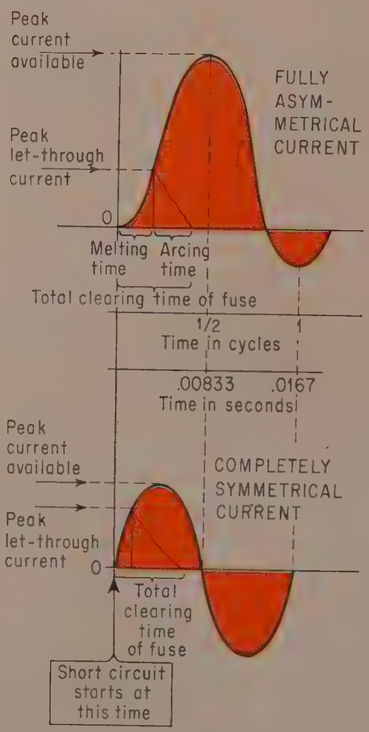
Selection Factors

Selection of a fuse for any circuit protection task involves the following considerations:

1. Current rating of the fuse must be correct for the electrical conditions of the circuit which it is to protect. Normally, the fuse must be rated to automatically open the circuit if the current flowing reaches a value which will cause an excessive or dangerous temperature in the conductor or conductor insulation or in other equipment being protected. Specifically, fuses must be rated to protect conductors in accordance with their safe allowable current-carrying capacities. Of course, where standard ampere ratings do not correspond with conductor carrying capacities, the next larger standard size of fuse may be used, e.g., a 3/0 type R wire, rated at 165 amps, may be protected by a standard 175-amp fuse.

But the NE Code and modern engineering practice recognize certain cases where circuits may be protected by fuses rated in excess of the allowable current-carrying capacities. Such is the case of short-circuit overcurrent protection

C—Action of Current-Limiting Fuses



For a given short-circuit, a current-limiting fuse may be called upon to interrupt either of the two extreme conditions shown here or some intermediate condition. For the fully asymmetrical case, the fuse would limit both RMS value and peak available current if the melting time of the fuse were anything less than one-half cycle. But, within its current-limiting range, a true current-limiting fuse must limit total clearing time to an interval not greater than the first symmetrical current loop and must limit the peak let-through current to a value less than the peak available current. Thus it is the action of a fuse in clearing a symmetrical short-circuit that determines its current-limiting ability, as shown in the lower sketch at left. From the sketch at upper left, it can be seen that a fuse which had a melting time almost up to the peak of the asymmetrical first half cycle, would limit current let-through on an asymmetrical fault, but would not limit let-through if the short happened to occur as a completely symmetrical wave.

The RMS value of the triangular wave shape of let-through current through the fuse is—

$$I_{LT} = \frac{I_p}{1.7}$$ where,

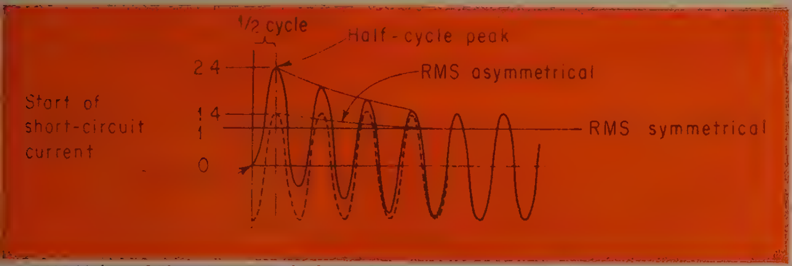
I_{LT} = RMS Let-Through amps

I_p = Peak Let-Through amps

B—Nature of Asymmetrical Current for Evaluating Fuse Performance

A fully asymmetrical short-circuit current has the highest possible instantaneous current obtainable for a given set of circuit conditions and voltage. A completely symmetrical current has the minimum peak on short-circuit. And a short-circuit of intermediate asymmetry will have an intermediate value of peak current. Because the fully asymmetrical condition constitutes the most severe interrupting problem, it is used in evaluating the ability of a short-circuit protective device.

On a fully asymmetrical short, maximum instantaneous current—the peak asymmetrical current—occurs at the end of the first half cycle of the current wave. Due to decay of the dc component, subsequent peaks are lower in value. Various values for this half-cycle asymmetrical current have been determined from study of actual circuits to be as follows:



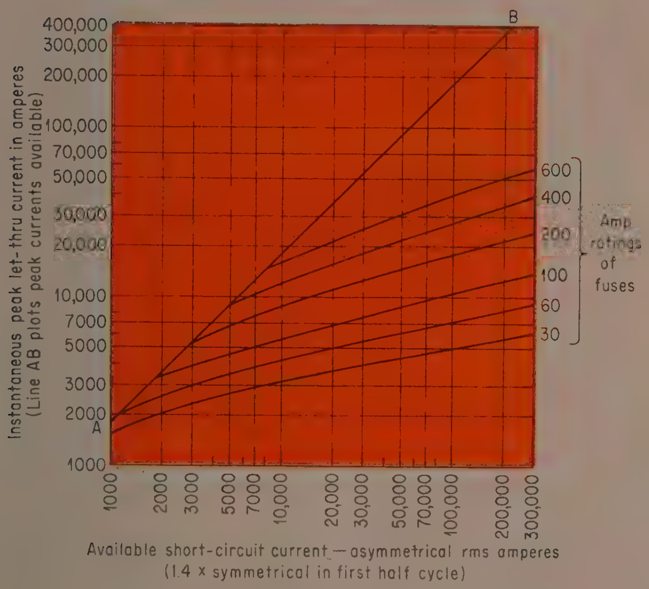
RMS Value of First Asymmetrical Half Cycle of the Current Wave = 1.4 × RMS Symmetrical Short-Circuit Current

Half-Cycle Peak Current = 1.7 × RMS Asymmetrical Current

Half-Cycle Peak Current = 2.4 × RMS Symmetrical Current

NOTE: The foregoing current values and relationships are essential to understanding and evaluating the various graphs of fuse performance made available by fuse manufacturers to facilitate effective and economical selection of fuses.

D—Typical Current-Limiting Performance



The line AB in the above graph indicates the maximum or peak instantaneous current corresponding to the first half cycle of asymmetrical short-circuit current. For any given value of available asymmetrical short-circuit current, the line AB plots the peak available current in the first half cycle (equal to 1.7 × asymmetrical rms amps or 2.4 × symmetrical rms amps of short circuit). This is the peak current which will flow if the fuse does not open before the current peak is reached. Where the curve for each size of fuse departs from line AB, the fuse is operating to limit let-through current for all values of available current above that value. For instance, a 20,000-amp asymmetrical short can produce a peak of 1.7 × 20,000 or 34,000 amps. But a 200-amp current-limiting fuse in such a circuit will open the circuit so fast that only about 11,000-amp peak is obtained.

for motors, in which cases the fuses may be rated up to four times the motor full-load current, which makes them much larger than the current rating of the branch-circuit conductors. This same "overfusing" is also used for motor feeders, and is permitted in both cases to allow the high starting currents of motors to flow without operating the fuses, which might readily happen if the fuses were rated for the current capacity of the conductors. In the case of a motor, it is felt that running overload protection will invariably take care of operating overcurrents, and the fuse will only be concerned with short-circuit or ground faults which are greater than four times motor current.

2. Voltage rating of the fuse must be at least as great as that of the circuit in which the fuse is being used. Fuses with 250-volt ratings must not be used in circuits of higher voltage ratings, although 600-volt rated fuses may be used with circuits rated at any value up to 600 volts.

3. Whenever fuses are used, they must be properly rated and suitable for safe operation at the level of fault current obtainable at the point of their application. Every fuse and circuit breaker for short-circuit protection must be applied in such a way that the fault current produced by a bolted short circuit on its load terminals will not damage or destroy the device. Specifically this requires that a short-circuit overcurrent device have a proven interrupting capacity at least equal to the current which the electrical system can deliver into a short on its load terminals. Application of short-circuit overcurrent devices without careful determination of their suitability on the basis of IC can present serious hazard to life and property. Thermal and magnetic forces released in short-circuit interruption can cause explosion—with flying pieces and propagation of flame—if the device is not designed, constructed and rated for the current it interrupts.

Where interrupting duty on a protective device is in the range from 100,000 to 200,000 rms symmetrical amps (or higher), fuses will almost always be required. In some cases, they will be the only suitable devices for the job. In other cases, their economy will far outweigh any advantages of an alternative CB. And the use of current-limiting fuses reduces the required short-circuit rating of load side equipment—switchboards and motor control centers can be braced for lower current levels.

4. Safe application of fuses does not stop with adequate interrupting for its own use at the point of installation in the system. The speed of operation of the fuse must always be studied in conjunction with the maximum fault current which could flow. This will reveal the "let-through" energy—the thermal and magnetic energy produced by the fault current from the time it starts until the fuse opens the circuit. And it should be remembered that if the short-circuit fault current happened to be, say, 40 times normal circuit current, the fault forces, which are proportional to the square of the current, would be in the order of 1600 times normal. A device may be able to break a given short-circuit without damaging itself in the operation; but in the time it takes to open the faulted circuit, enough energy may get through to damage or destroy other equipment in series with the fault. This other equipment might be cable or busway or a switch or motor controller which simply cannot withstand the few cycles of short-circuit current which flows in the period of time between initiation of the fault and interruption of the current flow. Therefore, the faster the fuse operates to clear a faulted circuit, the lower will be the thermal and magnetic forces acting on the circuit conductors and equipment.

5. Time vs current characteristics of the fuse should be suited to the requirements of the circuit. Time-delay fuse operation should be used to obtain freedom from nuisance blowing on motor inrush currents and other harmless current transients or momentary operating overloads. But fast-operating fuses should be used where there is no need for time delay—such as large size feeders and services where individual motor inrush currents or momentary overloads are masked by the nearly constant maximum current demand—or where fast operation in, say, a feeder will provide selective coordination with the main or service protection, opening the feeder only and not the main on a feeder fault.

Selective coordination requires careful study where fuses are used in the main, feeder, subfeeder and branch circuit levels of a system. Fuses of the same type—same operating characteristic—can provide coordination on the basis of size: on a given short-circuit current, the fuse with the lowest continuous current rating will open before any other similar type fuse of higher rating in the fault circuit.

6. The range of operating characteristics of a fuse must be carefully matched to the characteristics of a circuit breaker when the two are to function as a combination overload-short-circuit device.

Common application of dual protection uses combination units of molded-case circuit breakers with load side fuses. Such devices are used where the short-circuit duty exceeds that of the molded-case CB alone. The fuses have very high IC to meet the duty and have time-current characteristics to operate before the CB, in the range above the CBs IC. The CB provides overcurrent protection for operating overloads and ground fault and short-circuit currents up to its IC, with the fuses opening the circuit only on overcurrent which exceeds the IC of the breaker. In this way, full-load switching is obtained with the protection against single-phasing and easy reset on low-level overloads which are characteristic of CBs, while complete protection is obtained from the fuses. And substantial saving is made over the alternative use of larger breakers with full IC rating.

CIRCUIT BREAKERS

Selection of a circuit breaker for any application must consider the following:

1. **Current Rating**—The continuous current rating of a circuit breaker is, when applied in a specific circuit, generally considered to be one and the same as its trip rating. Selection of a specific current rating for any application must consider both the switching function and the overcurrent protective function.

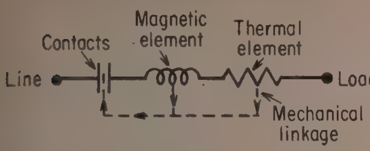
Usually a breaker is selected to have a trip rating which will protect circuit conductors in accordance with their safe allowable current-carrying capacity, i.e., the CB will open if the current reaches a value which will produce a dangerous temperature in the conductor or its insulation.

There are some exceptions to that rule. For instance, a CB protecting a motor branch circuit or feeder or a motor-and-lighting feeder may have its trip setting in excess of the conductor current rating to allow motor starting current to flow without tripping-out the breaker (NEC Tables 430-152 and 430-153). In such cases, time-delay overload protective devices, usually incorporated in the motor controller, will protect the conductors as well as the motor and the controller against operating overloads up to and including stalled-rotor condition of the motor. Overrated protection is also permitted for control circuits (Sec. 240-5). Another example of high-rating protection is that permitted for transformers. The NE Code recognizes the use of protective devices rated up to 250% of the full-load current of a transformer, to allow short-time overload operation which is within the design capability of the transformer (NEC Sec. 450-3).

Where standard ampere ratings and settings of circuit breakers do not correspond with the allowable current-carrying capacities of conductors, the next higher standard rating or setting may be used.

A circuit breaker provides effective control switching and performs easily as a load-break switch

Basic Thermal-Magnetic CB



One-pole diagram shows magnetic and thermal elements in series with breaker contacts and with circuit conductor. Up to its continuous current rating, the CB will carry current and neither the magnetic nor the thermal element will produce enough energy to trip the CB. But in the range from the CB current rating up to about 10 times the current rating, the thermal element will develop enough heat to deflect a bimetal strip and trip the breaker open. Time delay provided by the thermal trip assembly is inversely proportional to the value of current in this range. NEMA Standards set a maximum tripping time of 60 minutes at 125% of current rating and 2 minutes at 200% of current rating. Above 10 times current rating, the magnetic element generates enough force to trip the breaker instantaneously, operating before the thermal element. The thermal element is often called the "overload trip" and the magnetic element is called the "short-circuit trip." The sketch above shows a single-pole CB. For a multi-pole CB, each pole is arranged as above, but the poles are equipped for common trip so all poles open on overcurrent in any one pole.

for lighting and power circuits. It may be used as a motor controller if it has an ampere rating at least equal to the full-load running current of the motor. And it is permitted by the NE Code and good practice to be used as a motor circuit disconnecting means if it has a carrying capacity of at least 115% of the nameplate running current of the motor.

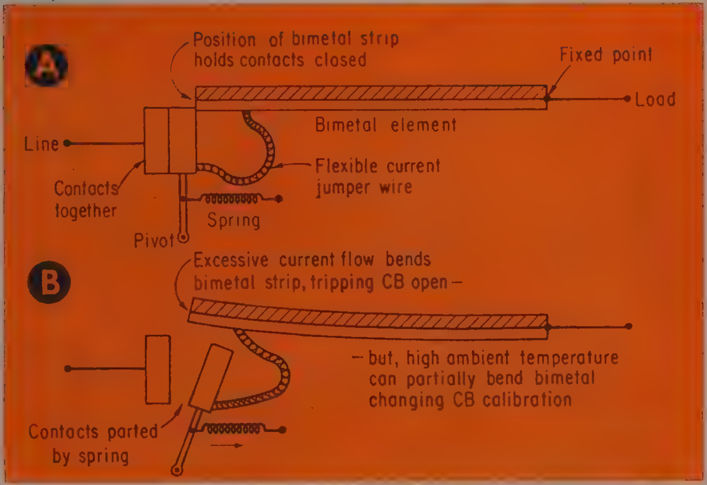
As used for overcurrent protection, a circuit breaker provides two types of protection: 1. Protection against operating overloads—too many lamps, or appliances, or motors connected to the circuit, so that the current drawn by the total connected load is in excess of the safe value for the circuit to carry; and 2. Protection against faults, failures to ground and short circuits, up to the interrupting rating of the breaker—that value of short-circuit current which the device is capable of opening safely without damaging or destroying itself in the process of interruption. In selecting a circuit breaker, its characteristics must be evaluated for both of these areas of overcurrent protection and correlated to the nature of the load on the circuit and the level of short-circuit current.

A circuit breaker with time-delay in its operation on overloads can be used to perform the functions of short-circuit protection and running overload protection for motor branch circuits. In such a case, the rating or setting of the CB must not be more than 125% of the motor nameplate current rating for 40°C rise motors and not more than 115% for other types of motors. This applies to all continuous-duty motors rated over one horsepower and to any motor one horsepower or less which is permanently installed, or is automatically started (by pressure switch, thermostat, time switch, float switch, etc.), or is out of sight from the location of its controller. Of course, to make such application, the CB must have sufficient time delay to pass motor starting current, taking into consideration the characteristics of the motor and the nature and torque requirements of the load. A single circuit breaker may, under the proper conditions, provide short-circuit protection, running overload protection, motor controller and disconnect means in a branch circuit to a motor.

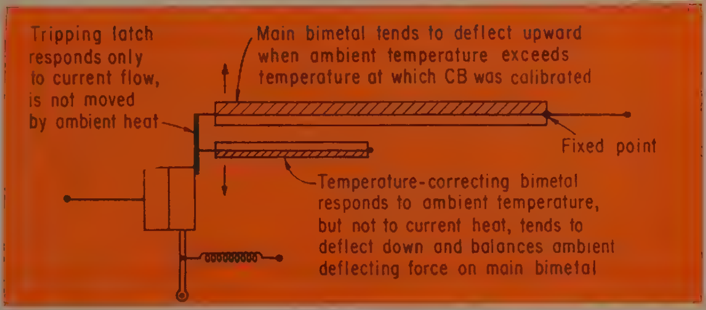
2. Interrupting Rating — Care must be taken in the selection of any circuit breaker to make sure that its short-circuit interrupting ability is satisfactory for the level of fault current which the electrical supply system is capable of delivering at the point of application of the breaker. A CB rated to interrupt 10,000 amps must not be used where, say, 15,000 amps could flow through a short circuit. The factors involved in such consideration are the same as those outlined in the previous discussion of fuses.

3. Voltage Rating—Selection of any CB must assure that the device

Ambient Temperature and Thermal Trips


A
Position of bimetal strip holds contacts closed
Fixed point
Load
Bimetal element
Line
Flexible current jumper wire
Contacts together
Spring
Pivot
B
Excessive current flow bends bimetal strip, tripping CB open—
—but, high ambient temperature can partially bend bimetal changing CB calibration
Contacts parted by spring

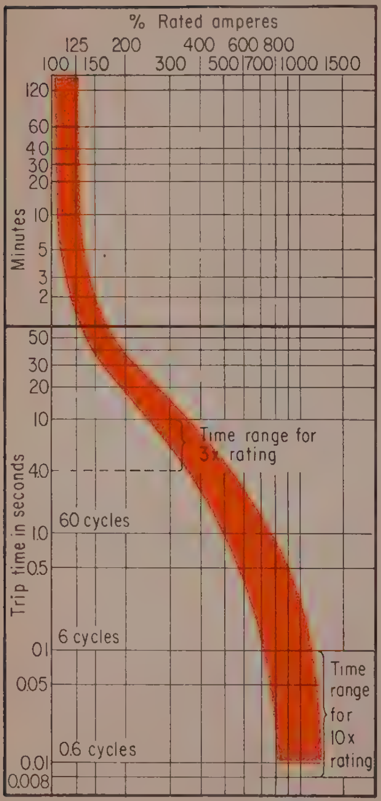
NOT TEMPERATURE-CORRECTED


Tripping latch responds only to current flow, is not moved by ambient heat
Main bimetal tends to deflect upward when ambient temperature exceeds temperature at which CB was calibrated
Fixed point
Temperature-correcting bimetal responds to ambient temperature, but not to current heat, tends to deflect down and balances ambient deflecting force on main bimetal

TEMPERATURE-CORRECTED

Temperature correction of thermal trip elements in circuit breakers insures a constant tripping characteristic, independent of ambient temperature conditions. This eliminates need for derating the CB and avoids nuisance tripping due to heat. Without temperature compensation, CB may have to be derated for ambient room temperature, for heat produced by enclosure and grouping of CBs and for duty cycle of load.

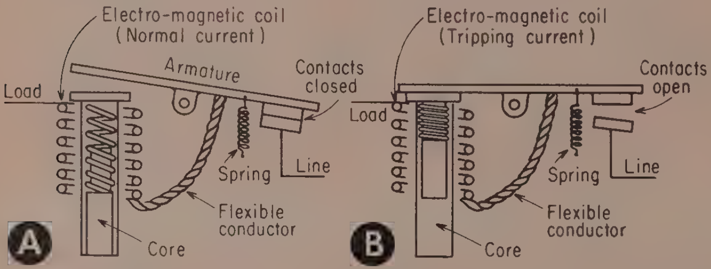
Typical Tripping Curve of Small CBs



The curve shows the tripping characteristic for a typical line of thermal-magnetic molded-case circuit breakers up to 70 amps. The curve shows the time in which a breaker will trip under a given condition of overload, expressed here as a percentage of the nameplate current rating of the breaker. The width of the curve represents the tolerance band to which the breakers are manufactured and within which all of the breakers will perform. The band can be taken to be a large number of line curves laid one against another. Operation from rated current (100%) up to about 10 times rated current (1000%) is provided by the thermal tripping device in the CB. Operation at 10 times rating and above is provided by the instantaneous action of the magnetic trip device.

Note that a load of 3 times rated current will trip the CB in no more than 10 seconds and no less than about 4 seconds. But at 10 times rated current, tripping time will be between about 0.1 seconds (6 cycles) and 0.008 second (less than ½ cycle).

Operation of Full-Magnetic Molded-Case Circuit Breaker



A fully magnetic molded-case circuit breaker employs magnetic means for both time-delay overload tripping and instantaneous short-circuit tripping. As shown in A above, normal current within the ampere rating of the breaker, flows through an electromagnetic coil connected in series with the contacts and the circuit conductor being protected. Within the magnetic coil, a hermetically sealed tube contains a sliding iron core immersed in a fluid and held by a spring at the end of the tube opposite the armature. Up to and including rated current of the CB, the core does not move in the tube and the armature is not attracted by the magnetic coil. But in the overload range up to 10 times rated current, the magnetic field of the coil draws the iron core into coil, overcoming the restraining spring and increasing the magnetic attraction on the armature until the armature moves against the coil (B above) and the CB trips open. The fluid in the tube delays movement of the core, thereby providing time delay inversely proportional to current flow. On short-circuit faults—10 times current rating or more—the magnetic field of the coil is sufficient to move the armature instantaneously, without movement of the core, quickly opening the circuit. Because this fully magnetic operation does not depend upon heat for its operation, its application can be made without regard for ambient temperature or derating. Such a CB can be loaded right up to its current rating under any conditions of temperature.

is rated for use at the level of circuit voltage.

4. **Number of Poles**—The number of poles required in a circuit breaker can be determined from the circuit and load conditions. As a protective device, the CB must have a current-responsive trip unit in each ungrounded conductor of the circuit. The code further states that an overcurrent device must not be placed in any permanently grounded conductor except: 1. Where the device simultaneously opens all conductors of the circuit, or 2. Where the device is used for motor running overload protection in the grounded leg of a 3-phase delta supply when three running overload units are required (Sec. 430-37, Note to Table). Then the question arises about use of single-pole CBs vs multi-pole CBs. The basic NEC rule requires a 3-pole CB for use with a 3-phase motor, but allows 1-pole CBs in 1-phase circuits.

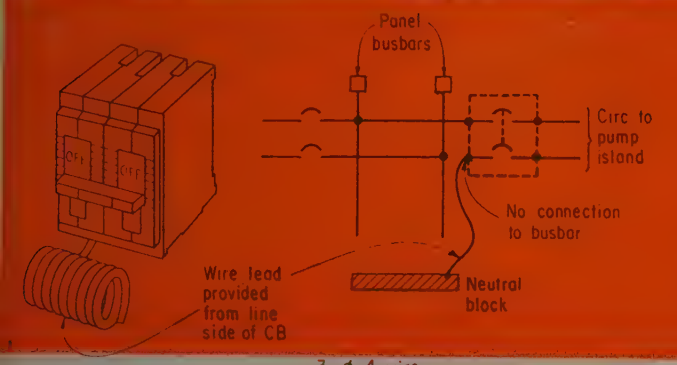
NE Code

In addition to the variety of code rules mentioned above, there are other code regulations which have a bearing on selection of circuit breakers, as follows:

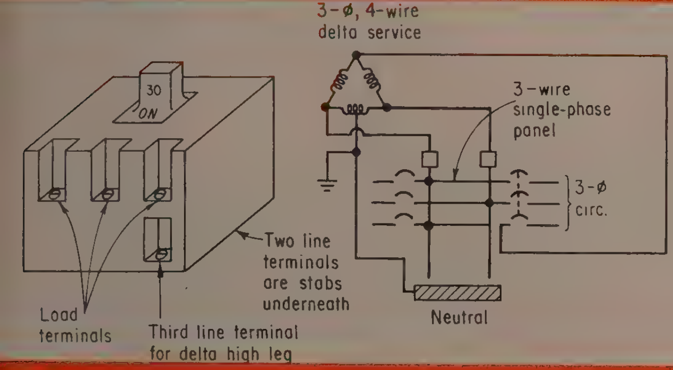
SERVICE DISCONNECT and overcurrent protection may be provided by circuit breakers. A manually operable circuit breaker equipped with a handle or other suitable operating means, may be used as a service disconnect if it is of a type approved for service equipment and for prevailing conditions. In addition to being manually operable, it may also be equipped for remote electrical operation. Where a single main disconnect is required, a single multipole CB can be used. If the six-subdivision allowance of the code [Sec. 230-70 (g)] is permitted, the disconnect may consist of up to six CBs. This may be six single-pole breakers or six multi-pole breakers. And two or three single-pole breakers connected on different ungrounded phase conductors of multi-wire circuits may be considered to be a single multi-pole breaker if they are equipped with handle ties or handles within $\frac{1}{16}$-in. proximity.

METHOD OF OPERATION must, in general, provide that a circuit breaker is capable of being closed and opened by hand with-

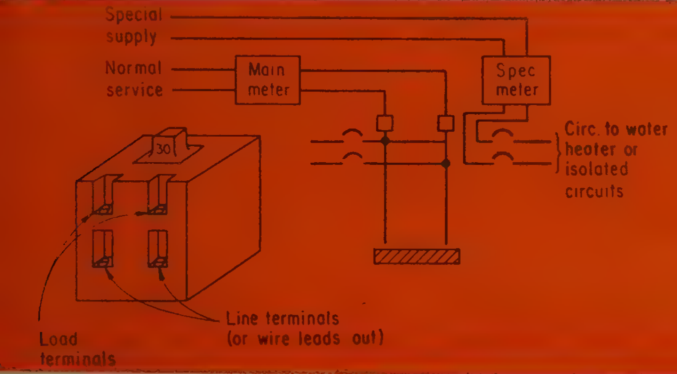
Special-Purpose CBs for Panelboards



SWITCHING NEUTRAL (Gas Station) CB for use in circuits to gasoline station dispensing pumps, to comply with NEC Sec. 514-5, requiring disconnect of all conductors including neutral. Either 2- or 3-pole units may be used for 2-wire or 3-wire circuits, rated 15, 20 or 30 amps. Ungrounded pole has overload trip elements. Neutral pole is simply a switching mechanism. No electrical connection is made to panel busbar by the plug in grip on the neutral breaker unit. Wire lead connects line side of neutral breaker to neutral block in panel, or two clamp terminals are used for neutral


3-ϕ, 4-wire delta service
30
ON
3-wire single-phase panel
3-ϕ circ.
Two line terminals are stabs underneath
Load terminals
Third line terminal for delta high leg
Neutral

3-POLE CB WITH SPECIAL TERMINAL layout provides for readily deriving a 3-phase circuit from a single-phase panel fed by a red-leg delta service. CB unit plugs into space of three single-pole breakers, with high leg of delta feeding directly through one pole of the common-trip assembly. Unit may protect motor branch circuit or feeder to 3-phase panel, rated up to 100 amps.


Special supply
Normal service
Main meter
Spec meter
Circ. to water heater or isolated circuits
30
Load terminals
Line terminals (or wire leads out)

ISOLATED TERMINAL BREAKERS are used for connecting hot water heaters to separately-metered, off-peak power sources. One- and two-pole units are rated up to 30 amps. CB unit plugs into panel with stab devices merely securing the unit in position. No electrical contact is made with panel busbars. Some units have clamp-type terminals for both line and load wires; others have wire leads provided as part of the assembly. This isolated terminal breaker is also used to supply emergency circuits from an alternate source of supply.

but employing any other source of power, although normal operation may be by other power such as electrical, pneumatic and the like. Large circuit breakers which are to be closed and opened by electrical, pneumatic or other power shall be capable of being closed by hand for maintenance purposes and shall also be capable of being tripped by hand under load without the use of power.

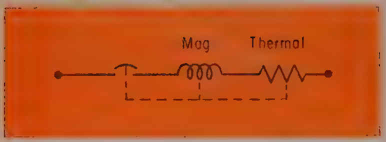
CBs RATED 0 TO 30 AMPS must be of the time delay type.

NAMEPLATE RATING on circuit breakers must be marked to be visible after installation. Any circuit breaker intended to interrupt fault currents greater than 10,000 amps must have its interrupting rating shown on the label or on the product.

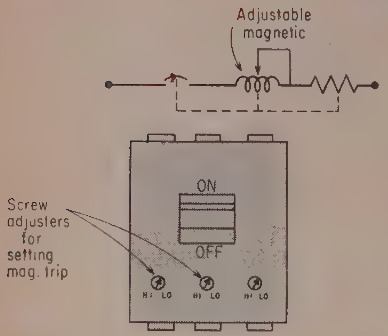
NON - INTERCHANGEABLE circuit breakers must be used in lighting and appliance branch circuits in residential and other occupancies where the conditions of maintenance and supervision do not assure that the overcurrent protective devices and branch-circuit wiring will be maintained at proper rating. Type NI (non-interchangeable) breakers and the bussing and mounting provisions in panelboards must prevent (or, make difficult) the replacing of a CB with one of higher ampere classification, based on three classifications—0-20, 21-50 and 51-100 amps.

To fill the range of circuit-breaker applications, there are two basic types of breakers according to general construction: the molded-case CB and the power CB. There is some overlap in the continuous current ratings of these devices, but the power CB is a larger, heavier-duty device than the molded-case breaker, has generally higher short-circuit interrupting ratings and is available with current ratings up to 6000 amps, whereas the molded-case devices only go up to 1000 amps. Use of current-limiting fuses in molded-case CBs extends applications.

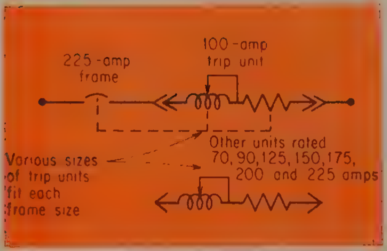
Selecting Type of Circuit-Breaker Trip Units



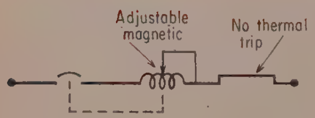
Non-interchangeable, thermal and fixed magnetic trip elements are factory calibrated and sealed for one current rating. Magnetic instantaneous trip is set for about 10 times the thermal trip setting. Such CBs are available in the many types of small, lighting-panel breakers and in larger units where fixed circuit loading and other conditions do not require the more expensive interchangeable trip models. Typical units are rated 10—400 amps.



Non-interchangeable, thermal and adjustable magnetic trip elements are calibrated and sealed as to the trip setting of the thermal trip, thereby establishing the current rating of the CB. The independent magnetic instantaneous trip can be field adjusted to operate anywhere from, in a typical case, 3 to 10 times the thermal trip setting, which is the current rating of the breaker. Adjusting of the magnetic trip varies the shape of the time-current tripping curve to meet load demands for more or less time delay on transient overloads or to provide coordination of overcurrent devices. Typical units are rated 15 to 400 amps.


225-amp frame
100-amp trip unit
Other units rated 70, 90, 125, 150, 175, 200 and 225 amps
Various sizes of trip units fit each frame size

Interchangeable, thermal and adjustable magnetic trip elements are unit assemblies which can be readily inserted or removed from breakers of one or more frame sizes (having the same dimensions). Each interchangeable trip unit contains a thermal trip device set to some value of current and a magnetic trip element which can be adjusted as to the current value which will produce instantaneous operation. The thermal trip is calibrated and sealed at the factory. The magnetic trip is field adjustable to multiples of the thermal setting. Breakers of this type offer flexibility of increasing or decreasing the current rating of the breaker to meet changes in circuit or load conditions, plus the ability to alter the point of instantaneous trip. Typical units are rated from 70 amps up.



Magnetic-only, instantaneous trips are used in breakers to give them only a short-circuit interrupting ability, with no protection in the overload range from the nominal amp-rating of the CB up to the current setting of the magnetic trip. Such CBs are made with either interchangeable or non-interchangeable magnetic-only trip units. The continuous current rating is taken as the nominal amp-rating of the CB as required by the continuous load current.

Molded-Case Breakers

A molded-case circuit breaker is a circuit-breaker mechanism assembled as a complete switching and overcurrent protective device in a supporting and enclosing housing of insulating material. For modern circuit applications, such units are made in sizes from 10 amps up to 1000 amps, with one, two or three poles, for circuits rated up to 600 volts.

Molded-case CBs are divided into size groups on the basis of frame sizes. A given frame size embraces a range of ratings of CBs which have the same size molded case, the same rating of contacts and the same interrupting rating. The continuous current rating of any CB is determined by the rating of its trip element. The cases of a given frame size are, therefore, physically interchangeable, with the exception of NI breakers, which have provisions to discourage unauthorized oversizing of protection. The frame size is designated by referring to the largest ampere rating available in that group, e.g., 100-amp, 225-amp, 400-amp.

Short-circuit interrupting capacities of molded-case circuit breakers vary with frame size and with voltage rating. Molded-case CBs may have ICs up to 75,000 rms amperes by themselves and over 200,000 rms amperes when current-limiting fuses are used in conjunction with the CB unit.

Molded-case CBs may have thermal-magnetic or fully magnetic trip operation. Both types are shown in accompanying illustrations.

Many types of small CB units are made in the range from 15 to 100 amps. Where switch control is required at the panel CB, units with quick-make, quick-break contact operation offer longer, more reliable life. And where required by voltage or where IC exceeds 5000 amps, E-frame CBs can be used up to 10,000 amps or F-frame CBs up to 20,000 amps.

Some molded-case CBs—in the range of sizes up to 100 amps—have non-interchangeable trip mechanisms of fixed operating characteristics. Others—in the larger sizes—have adjustable short-circuit trip elements which may also be interchangeable.

Power Breakers

Low-voltage power circuit breakers, also called large air breakers, are heavy-duty switching and protective devices with high interrupting capacities. Such CBs have rugged contact assemblies, provisions for arc suppression, either manual or electrically powered operation. They are available either as individually mounted units—in wall or floor mounting enclosures—or in switchboards or load-center substations. Typical characteristics of low-voltage power breakers are as follows:

1. Available in ratings from 15 amps up to 4000 amps, continuous current, in ratings of 240, 480 and 600 volts.
2. Interrupting ratings vary with size and voltage rating from 15,000 up to 150,000 rms amps asymmetrical (and beyond 200,000 amps in combination with suitable current-limiting fuses).
3. Fully magnetic tripping characteristics based on as many as three individual elements—long time delay, short time delay and instantaneous trip. These separate elements may be used singly or in any combination to accomplish time-current curve shaping for any selective coordination scheme. Adjustments are provided for the long and short time-delay pickup settings. The instantaneous trip may be set at the factory or may be adjustable.

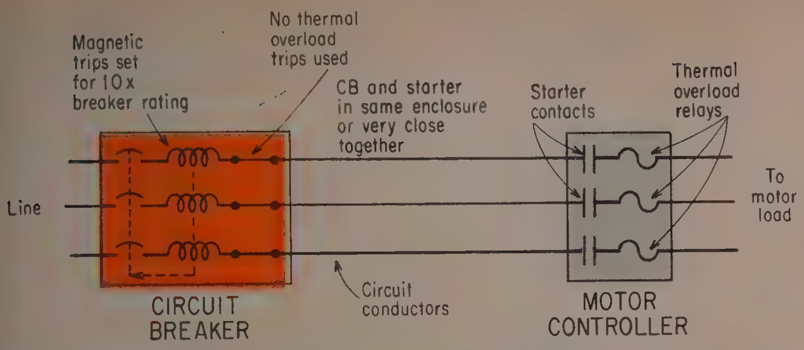
Low-voltage power circuit breakers provide for circuit-breaker application above the range of molded-case CBs (1000 amps). They are suited to applications where high frequency of switching operation demands a rugged unit to handle heavy current, even within the molded-case range.

High-Voltage CBs

High-voltage power circuit breakers provide load switching, short-circuit protection, electrical operation, adjustable time delays of trip characteristics for selectively coordinated protection schemes, quick reclosing after tripping and various relay protective hookups such as differential relay protection of transformers. There are both oil type and oilless (or air-type) CBs, although the oilless type is the common type for indoor applications in systems up to 15 kv and higher. Oil CBs are generally used for outdoor applications above 15 kv. Power CBs are made available in completely packaged assemblies.

Short-circuit ratings of CBs should be based on asymmetry factors correlated to speed of CB operation and circuit X/R ratios.

Function of "Magnetic-Only" CB


Magnetic trips set for 10x breaker rating
No thermal overload trips used
CB and starter in same enclosure or very close together
Starter contacts
Thermal overload relays
Line
To motor load
Circuit conductors
CIRCUIT BREAKER
MOTOR CONTROLLER

Molded-case circuit breakers with only magnetic instantaneous trip elements in them are available in almost all sizes. Use of such a device requires careful accounting for the absence of overload protection in the CB, up to the short-circuit trip setting. Such a CB is designed for use as shown above. The circuit conductors are sized for at least 125% of motor current. The thermal overload relays in the starter protect the entire circuit and all equipment against operating overloads up to and including stalled rotor current. They are commonly set at 125% of motor current. In such a circuit, a CB with an adjustable magnetic trip element can be set to take over the interrupting task at currents above stalled rotor and up to the short-circuit duty of the supply system at that point of installation. The magnetic trip in a typical unit might be adjustable from three to ten times the breaker current rating, i.e., a 100-amp CB can be adjusted to trip anywhere between 300 and 1000 amps. Thus the CB serves as motor circuit disconnect and short-circuit protection.

Selection of such a CB is based on selecting a nominal CB size with a current rating at least equal to 125% of the motor full-load current, to carry the motor current and to qualify as a disconnect means under the NEC. Then the adjustable magnetic trip is set to provide the short-circuit protection, the value of current at which instantaneous circuit-opening takes place, which should be just above the starting current of the motor involved, using a multiplier of 1.5 on locked-rotor current for starting asymmetry.

Selecting A Magnetic-Only CB

In motor circuits, a CB with only an instantaneous magnetic trip may permit the use of a smaller size breaker than would be possible if a CB with standard thermal time delay and magnetic trips were used. The following example shows a typical case of such application economy:

Given: A 30-hp, 220-volt, 3-phase motor marked with the code letter M, indicating that the motor has a locked-rotor current of 10 to 11.19 kva per horsepower. A controller is also provided, with running overload protection in the controller to protect the motor within its heating damage curve on overcurrent.

Required: Select a circuit breaker which will provide short-circuit protection and will qualify as the motor circuit disconnect means.

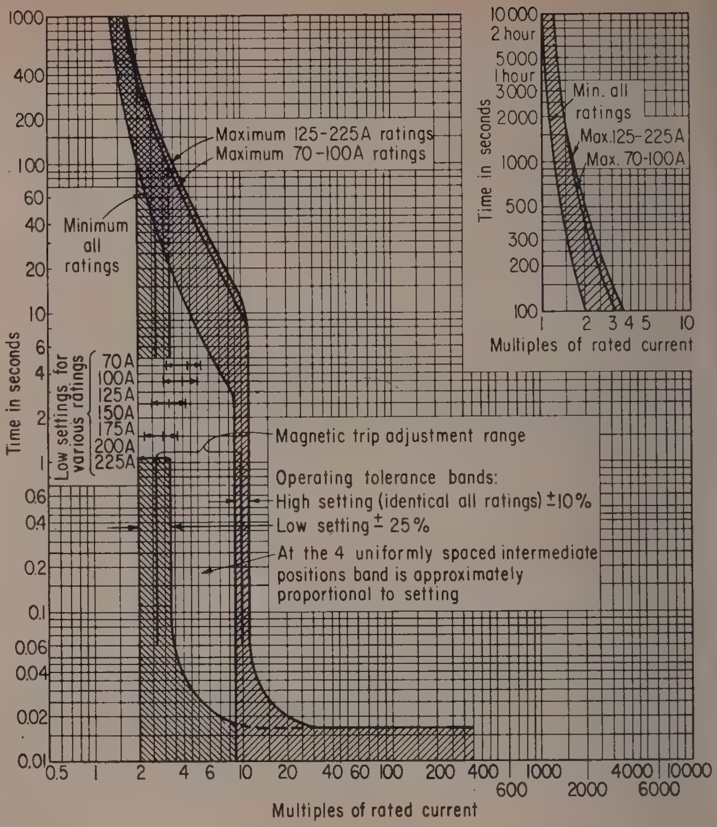
Solution: The motor has a full-load current of 78 amps (NEC Table 430-150). A CB suitable for use as disconnect must have a current rating at least 115% of 78 amps. The NE code, Sec. 430-52, will permit the use of a time-limit CB rated not more than 250% of motor full-load current (although a CB could be rated as high as 400% of full-load current if such size were necessary to pass motor starting current without opening). Based on 2.5 x 78 or 195 amps, a 225-amp frame size with 200-amp trip setting could be selected. The large size of this CB will generally take the starting current of the motor without tripping either the thermal element or the magnetic element in the CB. The starting current of the motor will initially be about 882 amps (30 hp x 11.19 kva per hp ÷ 220 volts x 1.73). The instantaneous trip setting of the 200-amp CB will be about 200 x 10 or 2000 amps. Such a CB will provide protection for grounds and shorts without interfering with motor running overload protection.

But consider use of a 100-amp CB with thermal and adjustable magnetic trips. The instantaneous trip setting at 10 times current rating would be 1000 amps, which is above the 882-amp locked-rotor current. But starting current would probably trip the thermal element and open the CB. This problem can be solved by removing the CB thermal element and leaving only the magnetic element in the CB. Then the conditions of operating overload can be cleared by the running overload devices in the motor starter, right up to stalled rotor, with the magnetic trip either fixed or adjusted to open the circuit instantaneously on currents above, say 1300 amps (882 x 1.5).

Because the use of a magnetic-only CB does not protect against low-level grounds and shorts in the circuit conductors on the line side of the starter running overload relays, such application should only be made where the CB and starter are installed as a combination starter in a single enclosure or are installed very close together, under controlled conditions.

Evaluating Trip Curves for Circuit-Breaker Selection

Curves show trip-time vs current for a 225-amp breaker with interchangeable trip units. Each trip unit consists of a fixed thermal trip element and an independent adjustable magnetic trip element. The various trip units give the breaker its particular continuous-current rating and are available in standard settings: 70, 100, 125, 150, 175, 200 or 225 amps. Then the adjustable magnetic element associated with each thermal can be adjusted from 3 to 10 times the current rating of the thermal trip. The curves are shown as bands to cover the tolerances to which the elements are manufactured and within which they will operate. A band can be taken to be a large number of line curves laid one against another. The curves here are shown as time vs multiples of any current rating (i.e., multiples of 70 amps or 150 amps or etc.). The two operating bands shown below 100 seconds represent the two extreme conditions of setting of the adjustable magnetic trip—3 times CB rating at left and 10 times CB rating at right. Intermediate settings of the magnetic trip would produce bands between the two shown here.

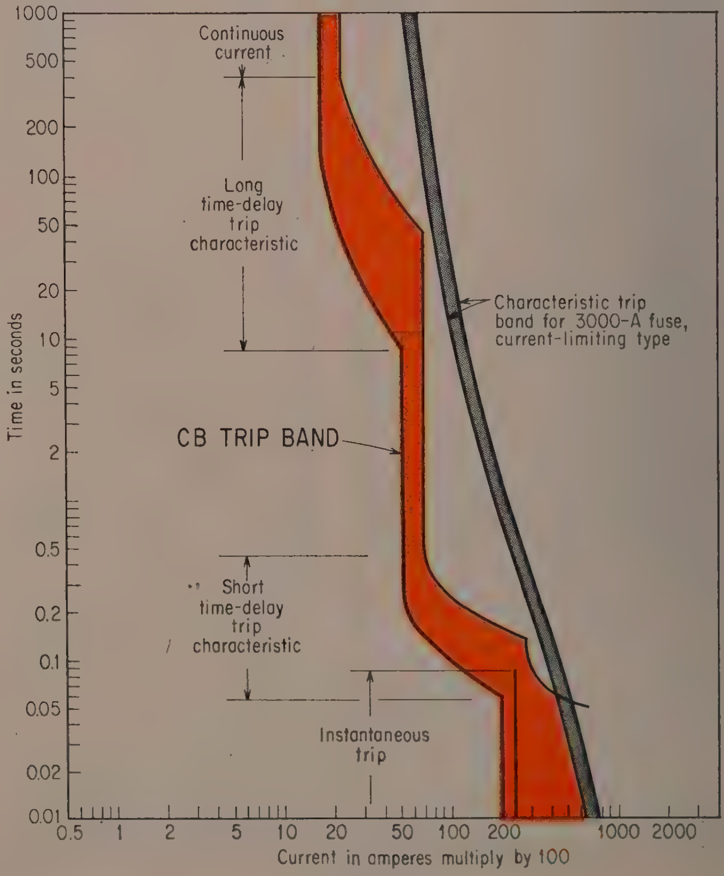


Typical Example of Combining Fuses with Circuit Breakers

Circuit-limiting fuses can be combined with both molded-case and power circuit breakers. A typical application is represented by the curves shown here. The fuses extend the maximum interrupting capacity of the CB to values above 200,000 symmetrical amps.

The 3-pole CB is an electrically operated low-voltage power circuit breaker with a continuous rating of 3000 amps and an IC of 75,000 asymmetrical amperes at 480 volts. The CB has three magnetic tripping characteristics in a 2000-amp rated trip device. The first, the long time-delay trip, is adjusted to pick up at 2000 amps. The second trip, the short time-delay trip, is adjusted to pick up at 6000 amps. The third trip is the instantaneous trip and is set for 12 times coil rating or 24,000 amps. The tolerance on pick-up settings is ± 15% for this trip device.

The time-delay trips are factory adjusted for minimum delays. The fuses used are rated at 3000-amp continuous carrying capacity with IC of 200,000 amps. The coordination between the fuse operating band and the breaker tolerance band is shown in the graph at right. The combination provides CB operation on faults up to about 60,000 amps with both devices operating above that value.



PANELBOARDS & SWITCHBOARDS

In the selection of switchboards, panelboards, secondary load-center unit substations and related components, it is usually advantageous to select standard unit-construction assemblies and/or components offered by a variety of manufacturers instead of requesting equipment requiring special or hard-to-get items. While this is not always possible, following this principle as much as possible will provide substantial savings in cost and will appreciably reduce delivery time. As a matter of fact, it will often be a wise choice to alter some job requirements to fit readily available equipment if this can be easily done. And in most cases, this will result in a better installation at a lower price.

Panelboards

Practically every electrical installation will require one or more panelboards. The NEC and NEMA define a panelboard as follows: “A panelboard is a single panel or a group of panel units designed for assembly in the form of a single panel, including buses, and with or without switches and/or automatic overcurrent protective devices for the control of light, heat or power circuits of small individual as well as aggregate capacity, designed to be placed in a cabinet or cutout box placed in or against a wall or partition and accessible only from the front.”

DISTRIBUTION PANELBOARD, shown in center, is rated at 1200 amps, 208Y/120 volts and contains five 200-amp fused subfeeder switches. Each 200-amp switch supplies two lighting branch-circuit panelboards as 10 such panels are located on single floor of a large office building. Typical lighting panels, with 15-amp, plug-in CBs are shown on each side of distribution panel.

Other pertinent NEMA definitions concerning panelboards are: “(1) Enclosed Panelboard. An enclosed panelboard is a panelboard provided with a suitable enclosure; (2) Panel-Base Assembly. A panel base assembly is a panelboard without cabinet or branch-circuit protective devices. It is designed for assembly in the form of a single panelboard, including buses, main connections and with provisions for future installation of two or more branch overcurrent devices, as required, without impairing dead-front features; (3) Cabinet. A cabinet is an enclosure designed either for surface or flush mounting and provided with a frame, mat or trim in which swinging doors are hung; (4) Lighting and Appliance Branch-Circuit Panelboard. A lighting and appliance branch-circuit panelboard is one having 10% of its overcurrent devices rated 30 amps or less for which neutral connections are provided; and (5) Distribution (Feeder) and Power Panelboard. A distribution (feeder) and power panelboard is a panelboard having switching and overcurrent protective devices primarily used as distribution circuits to lighting and/or appliance branch-circuit panelboards, to other distribution or power panels, and/or to feed a group of branch circuits other than lighting or appliance type.”

As a rule, lighting and appliance branch-circuit panelboards have bus ratings up to 225 amps, 600 volts or less, although larger bus ratings can and sometimes must be selected because of load requirements. The NEC limits this type of panelboard to 42 overcurrent devices (fuses or CBs) in any one cabinet. In addition, such panels (except as installed for services) supplied by conductors having overcurrent protection greater than 200 amps must be protected on the supply side by overcurrent devices rated not greater than that of the panelboard.

One factor of great importance concerns the carrying capacity of mains of lighting and appliance branch-circuit panelboards. Standards of UL and NEMA base the current-carrying capacities of main switches, overcurrent devices and busbars feeding lighting and/or appliance branch devices within the panel on an assumed average load current of not more than 10 amps per branch circuit. Where the continuous loading will be in excess of an average of 10 amps per branch circuit, busbars and integral main switches and overcurrent devices of greater capacity will be required.

Distribution and power panelboards are rated up to 1200 amps at 600 volts or less and contain branch devices generally rated 600 amps or less. Exceptions to these ratings are applicable to panelboards employing cast enclosures for special service conditions, and panelboards designed primarily for service equipment.

Panelboards approved for the purpose can be used as service equipment provided that the assembly can comply with the NEC six-switch rule, and the overcurrent devices for the service conductors do not exceed six per ungrounded pole. Typical arrangements include a panel with a single main fused switch or main CB feeding a number of small branch overcurrent devices; or two to six breakers or fused switches, one of which may or may not feed other overcurrent devices (via split-bus arrangements) within the same enclosure.

Generally, panelboards are available with fixed overcurrent device assemblies or plug-in or bolt-on type assemblies.

As applied today, the most popular type panelboards are those containing a panel-base assembly to which fusible units and/or circuit breakers can be attached. Such assemblies offer optimum selectivity to meet the varying requirements of each installation, thus

"Quality Chromalox manufacturing plus good distribution make an unbeatable combination"

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"I wouldn't put in anything but Chromalox electric comfort heating in my homes because of the quality of Chromalox equipment and the service I receive from my nearby Chromalox distributor. One third of the 30 homes I worked on last year were converted to electric comfort heating from another fuel. I find these customers are the most satisfied since they are able to compare the comfort of electric heating with the former source. My satisfied customers make an ideal sales force."

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Chromalox electric comfort heating has a double bonus for profit-conscious electrical contractors: one, the widest choice of electric heating equipment available anywhere; two, an opportunity to get the *entire* electrical job including the heating system which might be handled now by the heating contractor. So Chromalox can help you double up on the all-important profit column. Only electric comfort heating gives this double bonus.

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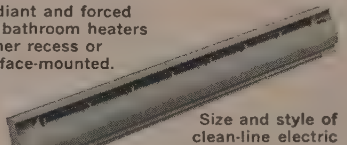

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METER CENTER consists of four standard 4-unit assemblies stacked vertically to provide 16 meters and disconnects for living units on each two floors of high-rise apartment building. The 4-unit meter assemblies are factory bussed on line and load side and 2-pole 70-amp CBs are plugged-in on load side of each meter. Notice that gutters on each side of stacked meter assemblies match over-all heights. Gutters simplify connection to main feeders and distribute subfeeder circuits.

avoiding costly custom equipment.

Panels containing plug fuses are required to have fuseholders of the Edison-base or Type S designs. As a practical matter, panelboards with non-removable plug-fuseholder assemblies are furnished with Edison-base types. Then, to conform to the latest NEC rules, Type S fuses and proper adapters, classified 0-15 amps or 16-30 amps, must be installed as designated by circuit ratings. However, it has been proposed that the 1962 NEC include three classifications for Type S devices instead of two. If adopted, the new classifications would be 0-15 amps, 16-20 amps, and 21-30 amps. Fuses and adapters in these categories are already available and are widely used.

With the detachable type plug-fuseholder assemblies, fuse blocks containing either Edison-base or Type S fuseholders are available.

Type NI circuit breakers and panel-base assemblies are required where circuit breakers are used for lighting and appliance branch circuits in residential and other occupancies except where the conditions of maintenance and supervision assure that overcurrent protective devices and branch-circuit wiring will be maintained at proper rating. Type NI circuit breakers, 250 volts or less, ac, are classified as follows: 0-20 amps; 21-50 amps; and 51-100 amps. Such breakers or their multiple mounting and bussing means must be arranged so that it will be difficult, after a CB has been installed, to replace it with a breaker of a higher ampere classification. Each manufacturer provides his own scheme for incorporating non-interchangeable features in his particular panelboard assemblies and plug-in breakers. Circuit-breaker enclosures listed by UL as non-interchangeable designs are marked Class NI.

A number of manufacturers of plug-in type CBs offer breaker units that provide two single-pole breakers or two double-pole breakers in the same space normally occupied by single units. This simplifies the addition of extra circuits in panelboards at a later date—and permits more breakers within smaller panelboards for new work. However, sound judgment is required when using such double-unit CBs so that panelboard busbars will not be overloaded.

For larger distribution panelboards, it is often advantageous to select free-standing panels, which can be mounted directly on the floor. This reduces labor costs and speeds up the installation. For mounting in or on walls, flush or surface-mounted panelboards are available.

Combination meter and distribution panelboards are available for installations requiring separate utility meters for each tenant within the same building. Such equipment contains two or more meter stab assemblies, factory-bussed line and load connections to meters, and panel-base assemblies. The panel-base assembly on the load side of each meter receives a plug-in feeder CB to which an individual tenant's feeder is connected. Several of such stock panelboards can be stacked vertically to meet the requirements of a particular meter load center. Then auxiliary pull boxes (available in various standard lengths) are installed on either side of the stacked panelboards for connecting and distributing feeder conduits and wire.

Wiring Terminals—When feeder cable sizes are not specified by the purchaser, panelboards generally employ pressure-wire terminals corresponding in size to the rating of the panelboard. As a rule, Type R wire is assumed for mains rated 100 amps or less; and Type RH wire is assumed for mains rated over 100 amps. In addition, it is further assumed that conductors no larger than 500 MCM will be used and that two or more terminals in parallel will be provided where greater current-carrying capacity is required. Panelboards containing terminals for aluminum and copper conductors are marked accordingly. If not so marked, the terminals are designed for the connection of copper conductors only.

Special panelboards can be obtained, which contain relays and contactors for applications requiring remote-control operation of various circuits. For use in wet, corrosive or hazardous locations, panelboards of approved types are available for such environmental conditions.

Switchboards

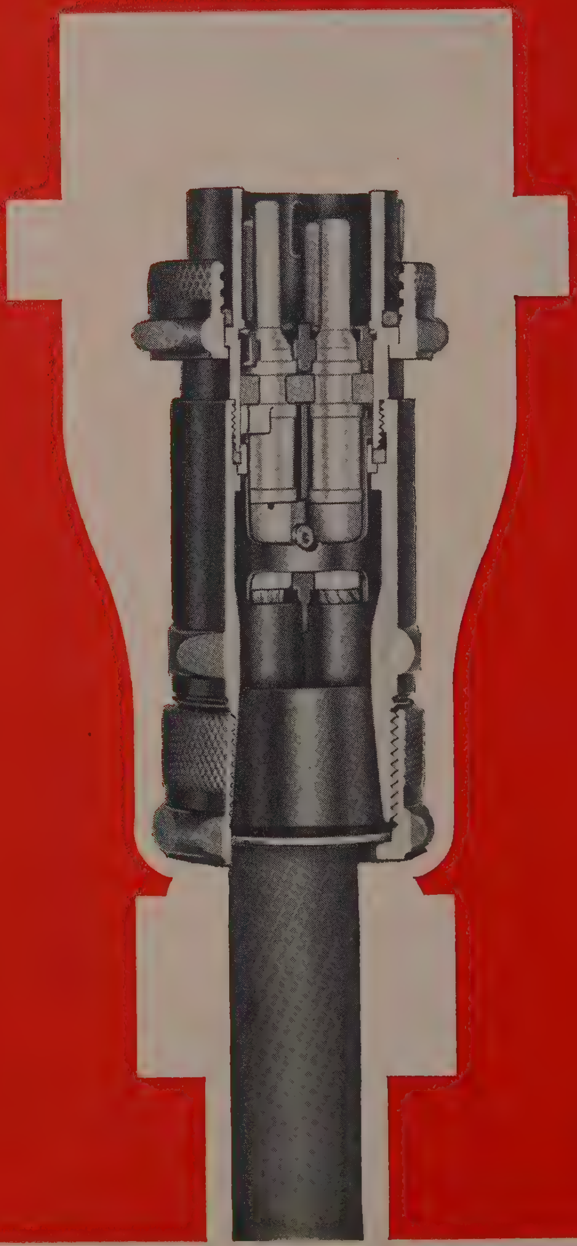
Switchboards contain switches, circuit breakers, fuses, metering equipment, relays or other forms of equipment which control or record electric current throughout a building. Discussions here are limited to metal-enclosed type switchboards, 600 volts or less, because of the high labor installation costs and infrequent use of live-front and dead-front-live-rear switchboards.

In general, metal-enclosed switchboards are rated from 800 to 6000 amps, at 600 volts or less, and for most installations they will contain the service disconnecting

FREE-STANDING, floor-mounted distribution panelboard contains 14 3-pole circuit breakers; ranging in size from 100 to 400 amps, which supply branch-circuit panelboards located in other parts of building. The 1200-amp distribution panel is fed from a main service nearby and occupies a minimum of floor space. Conductors are fed to panel via wireways and floor conduits.

PYLE-STAR-LINE ✷ the most compact environmental circuit breaking industrial connectors ✷ high power capacity ✷ require no special tools to assemble ✷ designed to resist severe environmental conditions.

white shape shows conventional plug size compared to Pyle-Star-Line



Available in 4 pole 350 MCM to 143 pole #16. For complete information write:
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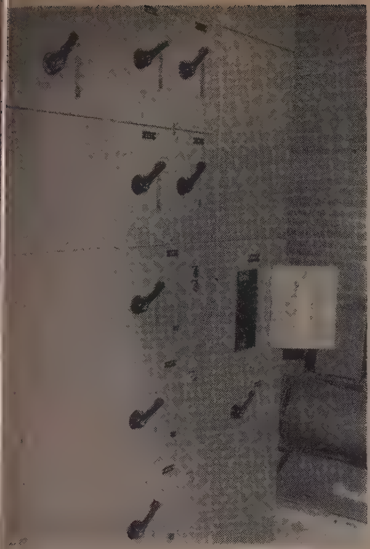


END SECTION of a large 480-volt, metal-enclosed switchboard combines feeder CBs, motor controls and a panelboard. Pushbutton stations and panelboard control equipment in vicinity of switchboards. Engraved nameplates identify equipment served by devices.

means and service overcurrent protective devices together with current transformers required for utility metering equipment. The most practical switchboards are those designed for free-standing floor mounting. And for purposes of shipping and delivery to the installation site, switchboards are shipped in two or more sections. However, each section should fit together with a minimum of field fabrication.

Busway, conduit or cable entries will vary with each job; and where a large number of raceways or cables will enter from the top of the switchboard, pull boxes extending the length of the board will simplify conduit or cable terminations and distribution of feeder conductors. When conduits enter the switchboard from below, buses and terminals should be elevated high enough to allow for conduit stubs, bushings and bonding conductors. As a practical consideration, the switchboard construction should be such that devices can be removed, interchanged or added in the field with ease.

Bussing arrangements should provide free access to the line and load terminals of devices. Busbars should be properly supported on rugged insulators of good dielectric properties, and they should be braced for anticipated short-circuit values. Material for busbars is silver-plated aluminum or copper with aluminum widely used due to lower costs.

As required, control and/or overcurrent protective devices for switchboards are available as power circuit breakers (stationary or draw-out types, and manually or electrically operated); manual or electrically operated high-capacity interrupter switches with Class L or Class M fuses; molded-case circuit breakers with or without current-limiting fuses; or standard or hinged-cover switches. A wide variety of indicating or recording instruments, designed for switchboard use, are readily available.

Secondary Unit Substations

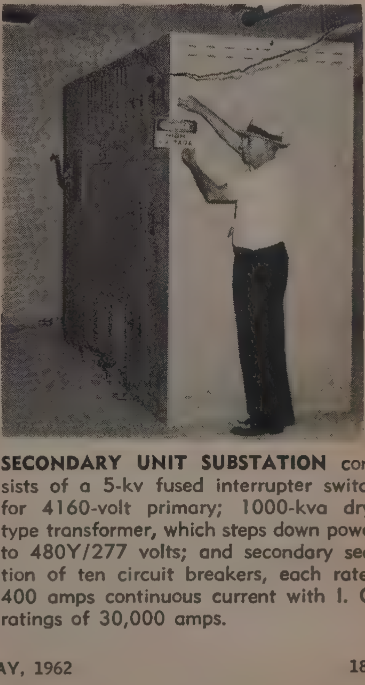
Factory-assembled, secondary unit substations can be obtained to fulfill the practical need of primary distribution systems serving large, scattered blocks of loads in industrial plants and high-rise commercial buildings. A number of major manufacturers offer complete packaged equipment with a wide selection of primary switchgear, transformers, secondary switchgear and related devices. Moreover, these manufacturers provide valuable equipment and technical data sheets, which greatly assist in the selection of unit subs and the systems to which they are connected.

Available for indoor or outdoor applications, the basic metal-enclosed secondary unit substation consists of an incoming section, transformer section, and outgoing section. Primary ratings range from 2.4 to 15 kv and secondary ratings are available for any of the conventional 3-phase systems at 600 volts or less. Equipment is shipped from the factory in two or three sections, and can be quickly bolted together on the job site.

In the past, all metal-enclosed substations were constructed of sheet steel. However, assemblies constructed of sheet aluminum are now available; and while they cost more than steel-constructed units, they have a specific advantage in outdoor applications or in other corrosive areas not favorable to steel. In addition, painting is not required for the aluminum housings.

The incoming line section consists of a metal cubicle in which primary feeders are connected to terminals or a disconnecting device. Typical primary devices include: (1) an air interrupter switch, fused or unfused, capable of interrupting loads up to 1200 amps; (2) a liquid interrupter switch (unfused) designed to interrupt load currents or only magnetizing current, depending on the type used. Some oil switches can interrupt currents up to 400 amps, while askarel-filled switches are usually suitable for interrupting magnetizing current only; (3) an oil-filled cutout which can interrupt loads up to 200 amps—5kv. This switch can be fused or unfused; (4) a draw-out, power air circuit breaker capable of interrupting required loads up to 3000 amps; and (5) an air-filled terminal junction box when isolating the substation is not required.

The transformer section will consist of oil-immersed, askarel-immersed, ventilated-dry-type or sealed-dry-type transformers. Oil-immersed transformers are generally used for outdoor applications, and are not permitted in buildings unless they are installed in an approved transformer vault. Askarel-immersed transformers can be installed in buildings and do not have to be located in a transformer vault provided that transformers rated over 25 kva are equipped with a pressure-relief vent and the primary supply does not exceed 15 kv. Ventilated dry-type transformers have a popular attraction because of lower maintenance costs than liquid-immersed units. Sealed-



SECONDARY UNIT SUBSTATION consists of a 5-kv fused interrupter switch for 4160-volt primary; 1000-kva dry-type transformer, which steps down power to 480Y/277 volts; and secondary section of ten circuit breakers, each rated 400 amps continuous current with I. C. ratings of 30,000 amps.

Any way you look at it–

New 600-volt ANACONDA Hot-Spot cabl
for the 90C-125C range cuts costs. .

...**WHEN YOU BUY IT**—Hot-Spot is a *butyl* cable—but butyl with a cost-cutting difference:

Rated 125C, Hot-Spot butyl gives you all the advantages of a high-temperature insulation—but *without* the traditionally high price tag. Here's why:

Before Anaconda developed Hot-Spot there was no rubber cable specifically designed for the 90C-125C range. Now Anaconda has succeeded in creating a 125C butyl to give you rubber flexibility with high heat-, moisture-, and cut-resistance—all at less cost than other high-temperature cables.

Because Hot-Spot is *specifically* engineered for the 90C-125C range, you never pay for overengineering; never run the risk of underengineering.

WHEN YOU INSTALL IT—Unlike ne high-temperature cables, Ana- ıda Hot-Spot is not stiff and hard to ıdle.

ts specially developed butyl couples h tensile strength with high flexibil- —*and flexibility is a key to low-cost tallation.*

Vith Hot-Spot, installation is quick l easy. No time is lost due to awk- rd handling.

'urthermore, though rated up to 5C, *its diameter is no greater than st standard 90C cables.* Therefore, if t spots are plaguing your present in- llation, you can use Hot-Spot cable thout the high cost of new conduit d fixtures.

. . . AS YOU MAINTAIN IT—*Hot-Spot cable lasts up to three times longer than standard cable in high-temperature applications.* This means it—

- doesn't get brittle.
- retains its tensile strength.
- has good cut resistance.

And it will outlast many existing high-temperature cables because it's highly resistant to moisture, particularly important during shutdown.

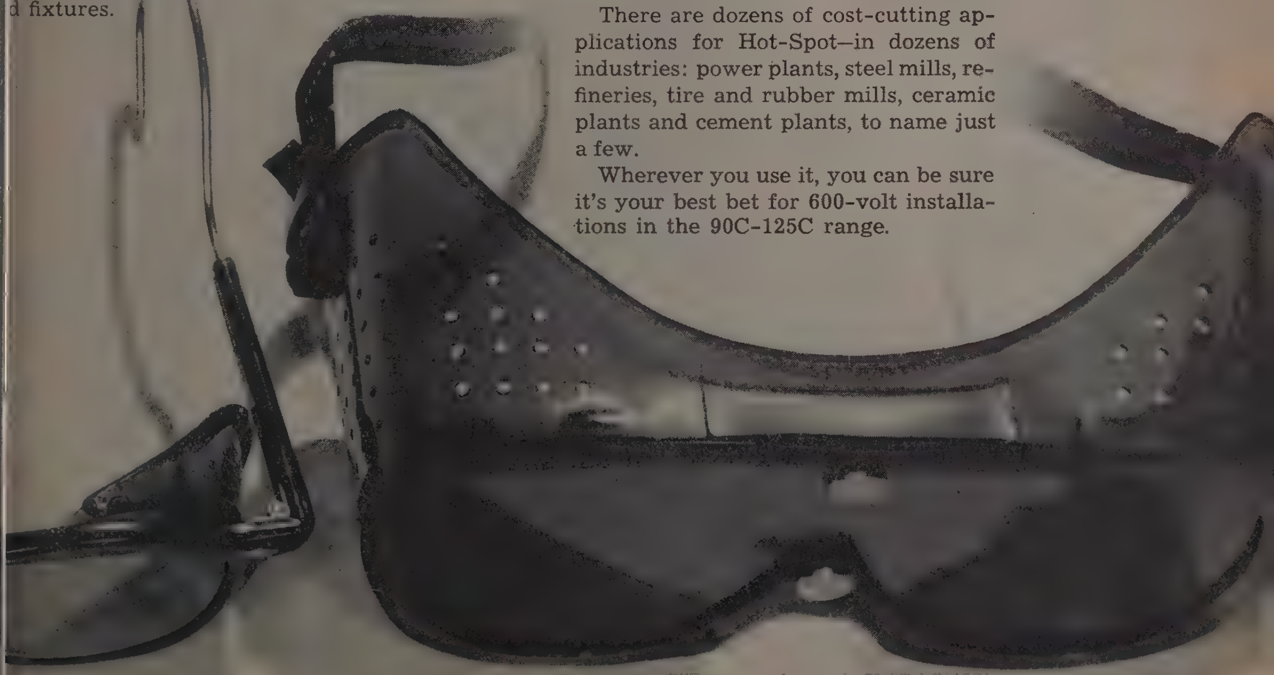
Because of these outstanding performance features, *your maintenance costs are cut to the bone.*

Because it outlasts ordinary cable three to one, *your replacement costs go down.*

Because of Hot-Spot's exceptional reliability, *downtime is minimized to help you realize optimum operating efficiency—and optimum profits.*

There are dozens of cost-cutting applications for Hot-Spot—in dozens of industries: power plants, steel mills, refineries, tire and rubber mills, ceramic plants and cement plants, to name just a few.

Wherever you use it, you can be sure it's your best bet for 600-volt installations in the 90C-125C range.



Start cutting cable costs now. Call your local Anaconda District Office or Distributor. Or write Anaconda Wire and Cable Company, 25 Broadway, New York 4, N. Y.

E ANACONDA HOT SPOT CABLE

Ask the man from
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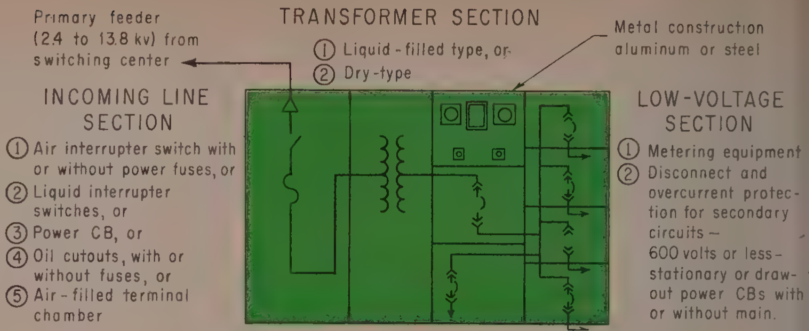
dry-type transformers are used where dusty or corrosive atmospheres prevail.

Primary voltage ratings are available up to 13.8 kv and typical transformer sizes range from 112½ to 3000 kva. Standard 3-phase secondary voltages are: 208Y/120, 4-wire; 480Y/120, 4-wire; and 240, 480 or 600, 3-wire.

The outgoing or secondary section generally consists of low-voltage power circuit breakers of the stationary type, or the draw-out type with separable main contacts. Breaker ratings vary from 15 to 4000 amps with interrupting capacities ranging from 15,000 to 150,000 amps.

Other major factors to consider in selecting secondary unit-substations include key-interlocking of interrupter switches; features of separable main and grounding contacts of draw-out type CBs; ease of removing or inserting draw-out devices; positive interlocks to prevent removal of power circuit breakers in the closed position; automatic alignment of line and load contacts to busbar stabs with draw-out equipment; pothead or clamp-type terminals for primary cables; grounding-bus connections between sections; and the type of indicating and recording instruments required. In addition, initial costs and subsequent maintenance costs should be considered in selecting the unit equipment available for the incoming, transformer and outgoing sections of the substation.

Basic Components of a Secondary Unit Substation


Primary feeder (2.4 to 13.8 kv) from switching center
TRANSFORMER SECTION
① Liquid-filled type, or
② Dry-type
Metal construction aluminum or steel
INCOMING LINE SECTION
① Air interrupter switch with or without power fuses, or
② Liquid interrupter switches, or
③ Power CB, or
④ Oil cutouts, with or without fuses, or
⑤ Air-filled terminal chamber
LOW-VOLTAGE SECTION
① Metering equipment
② Disconnect and overcurrent protection for secondary circuits — 600 volts or less — stationary or draw-out power CBs with or without main.

DRAWING INDICATES the various components that are available for the incoming, transformer and outgoing sections of typical secondary unit substations.

TRANSFORMERS

The use of higher distribution and utilization voltages in commercial and industrial electrical systems has stimulated increased application of modern transformers. This includes transformers for stepping from one primary voltage down to a second primary level, for stepping from primary down to secondary voltage (not over 600 volts), and for stepping a secondary distribution voltage to a secondary utilization level.

Various names are assigned to types of transformers according to their common use in electrical systems:

GENERAL-PURPOSE TRANSFORMERS are the dry-type units rated not over 600 volts and used for local step-down from a secondary distribution voltage to a utilization level. They serve lighting and appliance loads in all types of occupancies. Such transformers are also called "general power and light" transformers or simply "lighting" transformers. These include wall-mounting, ceiling-suspended and floor-standing units and also control transformers.

LOAD-CENTER TRANSFORMERS are either dry-type or liquid-filled units, primary rated from 2400 volts up to 15,000 volts and used for indoor and outdoor applications in high-voltage distribution systems to step to a voltage not over 600 volts. Such units may be used either separately, in combination with separate protective and switching devices and a separate secondary distribution switchboard, or they may be combined with primary and secondary switching and protection in a packaged unit substation—also called a "load-center substation." These are base-mounted, free-standing units.

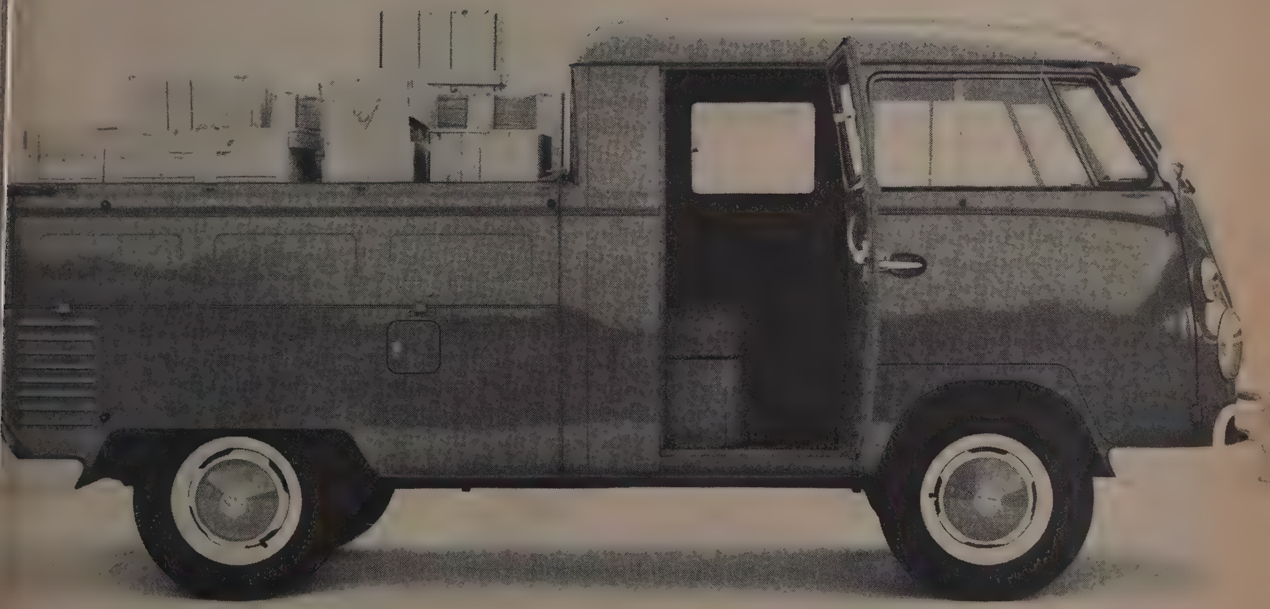
DISTRIBUTION TRANSFORMERS are single-phase and 3-phase, oil- or askarel-immersed, pole-mounting or platform-mounting units primary rated from 480 volts up to 15,000 volts, with step-down to a secondary level or to a lower high-voltage level in the case of units over 10-kv primary. This type of transformer—in capacities up to 167 kva—is used for pole-line distribution. Other outdoor wiring systems use platform units with ratings up to 500 kva.

SUBSTATION TRANSFORMERS are oil or askarel units primary rated from 2400 to 67,000 volts, with secondary ratings ranging from below 600 volts up to 15,000 volts. Such units are designed for use in utility distribution substations and in industrial substations. Power transformers are available for over 67 kv.

Basic Characteristics

Selection of a transformer for any electrical system application must cover the following:

1. VOLTAGE RATING — The primary and secondary voltage ratings of a transformer are determined very simply from the voltage rating of the supply to the primary winding and the required voltage level on the secondary. Both single- and 3-phase transformers



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Small back room for the gang.

This is a kind of Volkswagen gizmo.

Half truck.

Half car.

It'll take on 5 big guys any day.

And still give you as much room in back as an average half-ton pick-up.

Without the gang you even do better.

If you take out the back seat, you get another 65 cubic feet of cargo space inside. (You can even put the outside inside. We have hoops and a tarp that turn the bed into a covered wagon.)

Loading is easy. All 3 sides come down like tailgates.

And the bed's all flat. No wheel well. You use all the room for carrying stuff.

You get the VW air-cooled engine—no water to freeze or boil over. The VW traction in snow and mud. The legendary VW mileage.

And you get a truck and a car in one. We call this our 5-passenger pick-up and sell it for $2,085.*

There are cheaper gizmos in the world. But they don't hold 5 people.

Or go.

RATING DEFINITIONS

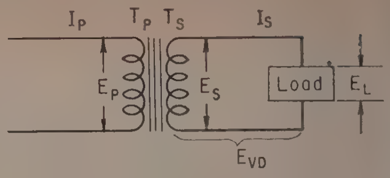
Rated Secondary Voltage of a Constant-Potential Transformer is the voltage at which the transformer secondary is designed to deliver rated kva.

Rated Secondary Current of a Constant-Potential Transformer is the secondary current obtained by dividing the rated kva by the rated secondary voltage.

Single-Phase Transformer Fundamentals

CIRCUIT CONDITIONS

E_P = Primary voltage
I_P = Primary current
E_S = Secondary voltage
I_S = Secondary current
E_{VD} = Voltage drop in circuit conductors
E_L = Voltage across load
T_P = Number of turns on primary
T_S = Number of turns on secondary



BASIC TRANSFORMER

PRACTICAL RELATIONSHIPS

$$\frac{E_P}{E_S} = \frac{T_P}{T_S} \qquad T_P \times I_P = T_S \times I_S \qquad \frac{I_P}{I_S} = \frac{T_S}{T_P} \qquad \frac{I_P}{I_S} = \frac{E_S}{E_P}$$

$$I_P \times E_P = I_S \times E_S \quad \text{Transformer kva rating} = \frac{I_P \times E_P}{1000} = \frac{I_S \times E_S}{1000}$$

EXAMPLE

What are the primary and secondary current ratings of a 50-kva transformer for stepping down from 480 volts to 240 volts?

$$I_P = \frac{\text{Transformer KVA Rating} \times 1000}{E_P} = \frac{50 \times 1000}{480} = 104 \text{ amps}$$

$$I_S = I_P \times \frac{E_P}{E_S} = 104 \times \frac{480}{240} = 208 \text{ amps}$$

NOTE: The above formulas do not take transformer losses into consideration and are, therefore, only approximate determinations. However, because transformers are extremely efficient devices (e.g., 98%), the calculations shown are generally acceptable for practical applications of transformers.

are made with a wide variety of voltage ratings to afford ready application in standard system configurations and even in non-standard arrangments.

To provide close application to practical system conditions, transformers can be selected with taps to adjust the transformer voltage to the correct primary or secondary voltage values. On general-purpose transformers, the primary is commonly provided with taps to vary the input voltage about 10%. A transformer with a 480-volt primary may, as an example, have four 2½% taps below normal rated voltage. This would mean, for instance, that the lowest tap would be to connect a primary feeder which operated at 432 volts (4 x 2.5% x 480 = 48 volts, which is subtracted from 480) to obtain the rated secondary output of 120/240 volts. If the 432-volt primary supply were connected to the 480-volt transformer terminals or to any of the other taps, the secondary voltage would be lower than 120/240. Taps allow compensation for system voltage drops.

General-purpose transformers have no-load tap changers, requiring that the transformer be de-energized when tap changes are made. Invariably, suitable taps for the given primary voltage are set once and left alone, unless some change in load conditions alters the voltage level at the transformer primary. On large transformers serving fluctuating demand loads, automatic tap changers which operate under load can be used on the transformer to maintain a constant voltage level at the transformer secondary terminals or at a remote point on the secondary output feeder.

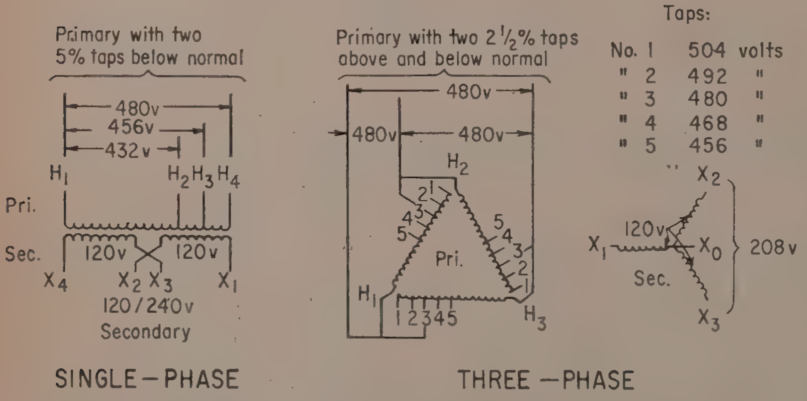
Selection of transformer taps should be based on establishing the no-load or maximum- voltage conditions at the transformer. Whether taps are above or below normal rated voltage, they should be selected to accommodate anticipated variations in supply voltage and, thereby, provide the required no-load secondary voltage. This will require taking into account voltage drops in secondary circuit to arrive at proper voltage levels at utilization devices—lights, motor, etc.

It should be remembered that transformer taps change the value of voltage transformation by changing the turns ratio of the windings. Because of this, the kva rating of a transformer is not changed by changing taps.

For given voltage rating, a transformer winding has a certain current rating, which determines the kva rating of the transformer. The ampere rating is a maximum value set by the impedance of the winding and the design capability of the transformer to dissipate heat. Conditions of use must not place a higher current on either primary or secondary winding. If the voltage input to a given transformer is reduced below normal, the maximum kva rating is reduced because the current cannot be increased to keep kva constant. And if overvoltage is applied, over-heating of the transformer will result with shortening of the life of the transformer.

In selecting a transformer, con-

Typical Voltage-Adjusting Taps



Common abbreviations: FCBN — Full-capacity below normal
FCAN — Full-capacity above normal

ALLIS-CHALMERS

new 3-piece case dry-type transformer

installs in 40 minutes flat!

Electrical contractors, maintenance engineers profit from as much as a 50% savings in man-hours per A-C unit installed! They're 35% lighter and smaller than before . . . are on the wall, wired, closed in 40 minutes instead of the usual 90 minutes. That means *lowest finished-job costs*, more profits when you consider both cost of the unit and installing time!

Thanks to this new simplified *3-piece case* design, common installation problems are eliminated. Convenient knockouts ease and speed hookup. Conduit bending is reduced or eliminated. Compact size means A-C units will go where conventional dry-types are squeezed out.

And these new units are whisper-quiet. Every known silencing factor is incorporated into this design . . . core impregnation . . . core and coil assembly isolated from case . . . and nonresonate casing is used.

• • •

This new dry-type, ventilated transformer line (600-volt class, indoor) is offered in 10 sizes, from 3 to 45 kva. *Your nearby A-C office will supply you with free Bulletin No. 61 B 8222C, or write Allis-Chalmers, Milwaukee 1, Wisconsin.* A-1601

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FREE PLASTIC PARTS BOX . . .

Permacel Plastic Electrical Tape—the superior insulating tape for your toughest jobs—now in a new package at no extra cost. A clear plastic box with adjustable partitions. Ideal for hundreds of uses in your tool or tackle box. In stock at your Permacel distributor now.

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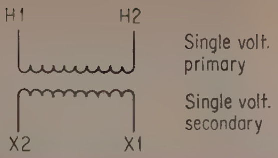
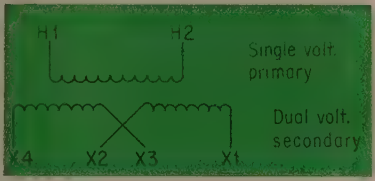
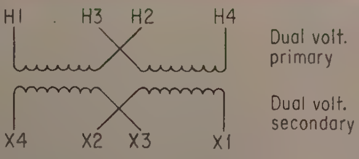
Basic Types of 1-Phase Transformers



Power is fed to primary at some voltage and is stepped up or stepped down to another voltage at secondary terminals.



Two sections of secondary can be connected in series or parallel, e.g., 480-volt primary to 120-volt secondary (parallel) or 240-volt secondary (series) or 120/240-volt (series) with mid-tap for neutral.



Primary can be connected to high or low value of voltage (2 to 1 ratio), e.g., 480 or 240 volts. Secondary connected as above.

Note: These transformers are available with and without voltage adjusting tap connections.

sideration of the "impedance" of the unit is involved in evaluating the ability of the transformer to supply short-circuit currents into faults on the load side of the transformer. The impedance of a transformer is the opposition which the transformer presents to the flow of short-circuit current through it.

All transformers have impedance and it is generally expressed as a voltage percentage. It is the percentage of normal rated primary voltage which must be applied to the transfomer to cause full-rated load current to flow in the short-circuited secondary. For instance, if a 480-volt to 120-volt transformer has an impedance of 5%, this means that 5% 480, or 24 volts, applied to the primary will cause rated load current to flow in the secondary. If 5% of primary voltage will cause such current, then 100% of primary voltage will cause 100/5 (or 20) times full-load rated secondary current to flow through a solid short-circuit on the secondary terminals.

From the foregoing, it can be seen that the lower the impedance of a transformer of given kva rating, the higher will be the short-circuit current which it can deliver. Take two transformers, each rated at 500 kva. The rated secondary load current is the same for both transformers. If one transformer is rated at 10% impedance, it can supply 100/10 (or 10) times rated secondary current into a short circuit on its secondary terminals. If the other is rated at 2% impedance, it can supply 100/2 (or 50) times rated secondary current into a short circuit on its secondary terminals. Thus, the second transformer can supply five times as much short-circuit current as the first one, even though they have the same kva load-handling ability. Common impedance values of general-purpose transformers are between 3% and 6%.

Voltage regulation is another transformer consideration and impedance is related to it. This is a measure of how the secondary voltage of a transformer varies as the load on the transformer varies from full load to zero, with primary voltage held constant.

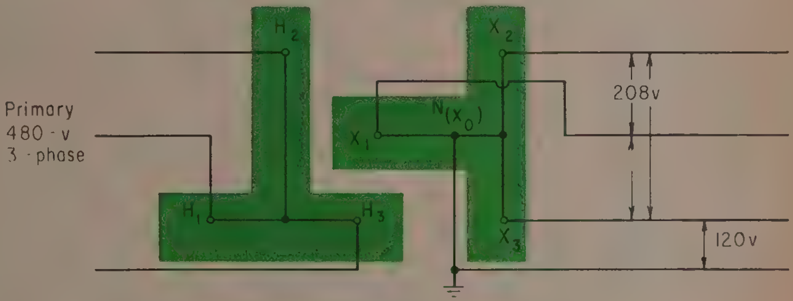
Regulation is expressed as a percentage—no-load voltage minus full-load voltage divided by full-load voltage times 100%. If a transformer has a no-load secondary voltage of 240 volts, and the voltage drops to 220 volts when the transformer is fully loaded (supplying rated current output), the regulation percentage is:

(240 − 220) ÷ 220 × 100% = 9%

This indicates that 9% of the secondary voltage is being dropped across the internal impedance of the transformer. It is obvious then that the higher the impedance of a transformer, the greater will be the drop from no-load to full-load and the higher will be the percent regulation. It is generally desirable to keep regulation as low as possible, to minimize variation in voltage as load-current demands vary. Typical regulation values are between 2% and 4%.

Low regulation becomes very im-

T-Connected 3-Phase Transformers



SIZE COMPARISONS—

	Conventional Design					T Design				
	Dimensions—in.			Sq. in. Floor Space	Cu. in. Total	Dimensions—in.			Sq. in. Floor Space	Cu. in. Total
KVA	Height	Width	Depth			Height	Width	Depth		
6	15	18-1/2	8-11/16	160	2400	22-1/2	8-5/8	7-3/4	67	1510
9	17-1/4	18-5/8	11-5/16	211	3640	25	8-5/8	7-3/4	67	1675
15	19	24	13-1/2	324	6150	26-1/4	11-1/4	9-7/8	111	2920

The T-connected transformer, made up of only two core and coil assemblies coupled vertically, offers advantageous application for voltage transformations in the range up to 15 kva. It provides practical 3-phase operation in a compact unit, with reduced overall size compared to conventional 3-phase transformers—as shown in the above table.

USS Armorlokt gives the protection of rigid conduit at one-half the cost

It's a simple job to install Armorlokt Cable around corners, over beams or down walls. That's because there are no costly pipe bends, fittings or pull boxes. It takes about twice the time to install a conduit system and larger size cable is needed because of the high voltage drop. The whole job costs about twice as much.

Armorlokt Cable is accessible its entire length, so it's easy to make splices or add new feeders. You get a far more flexible and revisable installation, one easily adapted to your future needs. Tiger Brand Armorlokt Cable is available in a complete range of sizes up to 4 inches in diameter—ratings up to 15,000 volts with insulations including varnished cambric, rubber and asbestos. You can have the cable armored with galvanized steel, stainless steel, aluminum or bronze. For especially corrosive applications, a polyvinyl chloride jacket can be applied over the armor. American Steel and Wire, Dept. 2246, Rockefeller Building, Cleveland 13, Ohio. USS, Tiger Brand and Armorlokt are registered trademarks.

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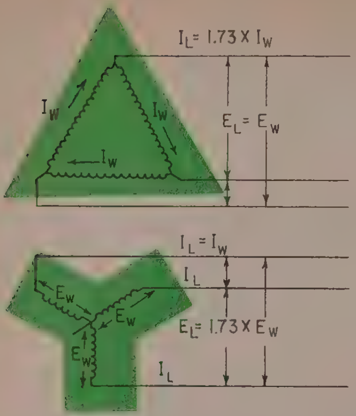
3-Phase Transformer Currents and Voltages



For Any Delta Connection (Pri. or Sec.):

$$I_L = \frac{\text{Rated Transformer KVA} \times 1000}{1.73 \times E_L}$$

For Any Wye Connection (Pri. or Sec.):

$$I_L = \frac{\text{Rated Transformer KVA} \times 1000}{1.73 \times E_L}$$

where, I_L = Line Current (Pri. or Sec.) of Transformer
I_W = Rated Current of Each Transformer Winding
E_L = Rated Voltage (Phase-to-Phase) of Transformer
E_W = Rated Voltage of Each Transformer Winding

Note: This data applies to 3-phase transformers and to single-phase transformers connected for 3-phase use.

portant when the transformer supplies varying load demands for utilization equipment which is sensitive to voltage changes. In cases where the load current on the transformer is relatively constant, however, taps on the transformer or primary supply conditions can be adjusted to provide a fixed compensation for the voltage drop in the transformer. Voltage level can be set as required at the utilization devices and will not change because load current is not changing. In such cases, acceptable voltage conditions at the utilization devices can be achieved with transformers of either low or high regulation.

But it should be pointed out that use of a high-regulation transformer gives the high internal impedance which reduces the level of possible short circuits on the secondary. As a result, fuses, circuit breakers and other protective devices will not have to be rated for as high interrupting capacities as they would have to be if a low-regulation (and low impedance) transformer were used.

2. KVA RATING—The rated kva output of a transformer is that load which it can deliver for a specified time, at rated secondary voltage and rated frequency, without exceeding a specified temperature rise based on the insulation life and ambient temperature. The output which a transformer can deliver without deterioration of the insulation may be more or less than the rated output depending upon ambient temperature and load cycles.

Transformers may be loaded above rated kva with no sacrifice of life expectancy only in accordance with prescribed temperature testing or short-time loading data from the manufacturer. In addition, the load that can be carried on self-cooled transformers can be increased considerably by the use of fans or other auxiliary cooling equipment. Such application may be advantageous for short-time peak loading, although design characteristics of the transformer must be considered, including increased voltage regulation.

The basic loading conditions which determine selection of a transformer for normal life expectancy are:

1. The transformer is continuously loaded at rated kva and rated voltage.

2. The average temperature of the cooling air during any 24-hour period is equal to 30°C.

3. The temperature of the cooling air at no time exceeds 40°C.

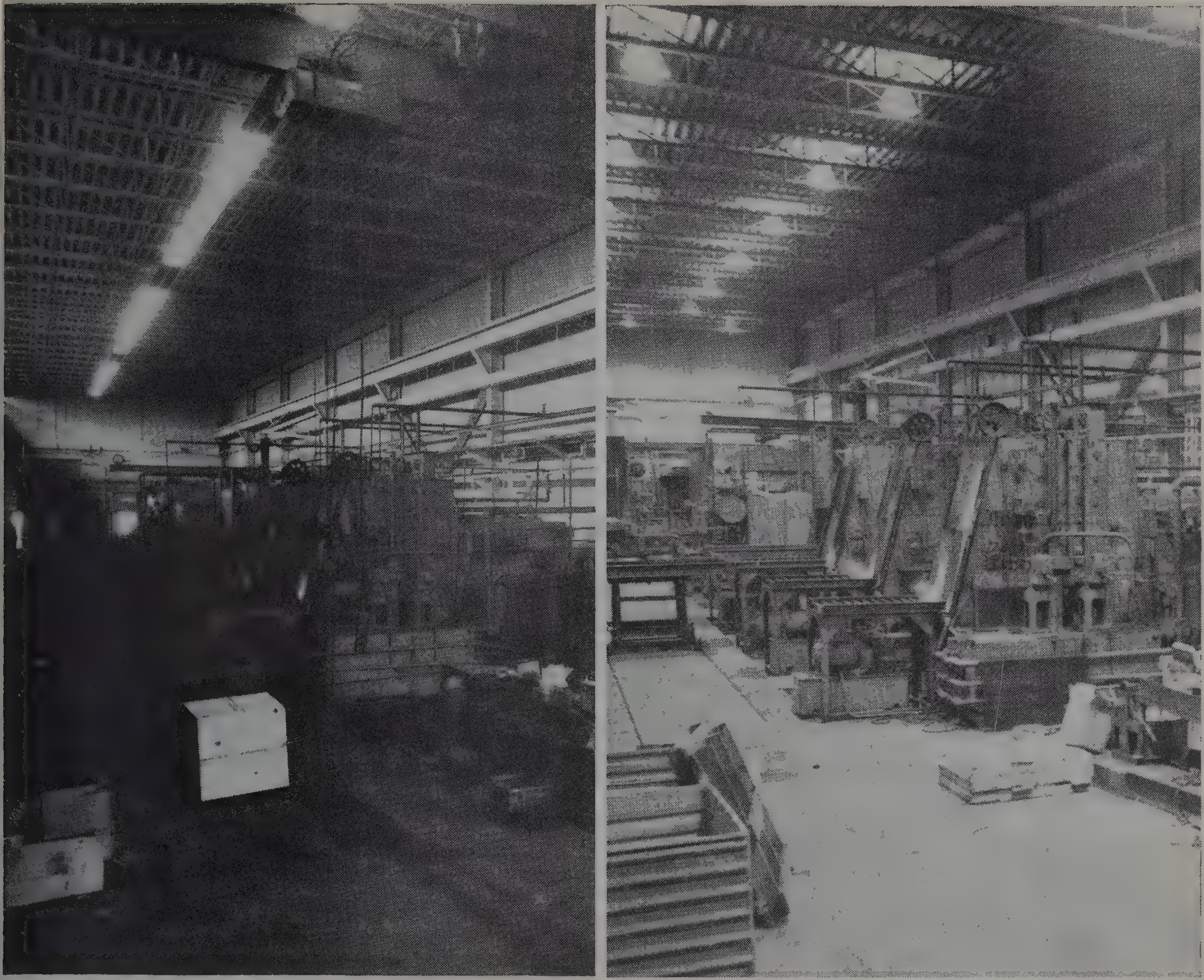
The rated kva, rated voltage and rated primary and secondary currents are considered to be maximum values. Rated kva is based on drawing rated current at rated voltage, but the kva handling capacity cannot be kept constant by, say, operating at lower voltage and higher current. The kva rating is set by the maximum current the transformer can carry without reaching a dangerous temperature. This current cannot be exceeded. And it should be noted that transformer rating is in kva which makes its load-handling ability independent of circuit power factor.

Selection of a transformer involves choosing a unit which has a kva rating at least equal to the kva rating of load to be supplied. But modern engineering practice, based on experience with load growth in electrical systems, demands inclusion of spare capacity in every transformer installation. Of course, this spare capacity will be provided automatically if the feeders and branch circuits supplied by the transformer have spare capacity.

In selecting transformers to supply motor loads, there are several general rules used to determine required kva capacity. One such rule says that a transformer should have at least one kva of capacity for each hp of motor load. Another guide suggests at least 1¼ kva per hp of motor load for motors rated 5 hp and above. Motors over 50 hp may require less than 1¼ kva per hp. Of course, extreme accuracy can be achieved in matching transformer capacity to a given number of motors if the nameplate current ratings of the motors are added together and then multiplied by rated voltage to obtain kva.

3. FREQUENCY RATING—By far the most common frequency of alternating current used for modern power and light electrical systems is 60 cycles. Transformers used on such systems are correspondingly rated for 60 cps. Where other frequencies are used, care must be taken to assure suitability of transformers.

4. NUMBER OF PHASES—Single-phase transformers are used on single phase systems and on a single-phase of 3-phase systems. For transforming 3-phase voltage from one level to another, either three single-phase transformers can be connected for the task or a three-phase transformer can be used. A 3-phase transformer generally weighs less and takes less space than three single-phase transformers of same type, construction and total kva capacity. But the use of three single-phase transformers has the advantage that failure of one of the units requires that only the one unit be replaced. Any failure in a 3-phase transformer requires replacement of the entire assembly.



Before-and-after photos taken at Dayton Forging & Heat Treating Co., Dayton, Ohio

Now here's a switch. The lighting level is up, costs are down

INSTALLATION DATA

Abolite HMFAU-1800 Alzak aluminum uplight fixtures with 400 watt color-improved mercury lamps. Mounting height 20′, spacing 9 x 16′. Average maintained footcandle level: 40.

Lighting engineer:
Mr. Tom Baughman,
Dayton Power & Light Co.

In this heat treating room, high temperatures were causing both ballast failures and premature lamp burnouts in the extra high output fluorescent system. Even worse, the dull dreary lighting reduced worker efficiency, made some jobs hazardous.

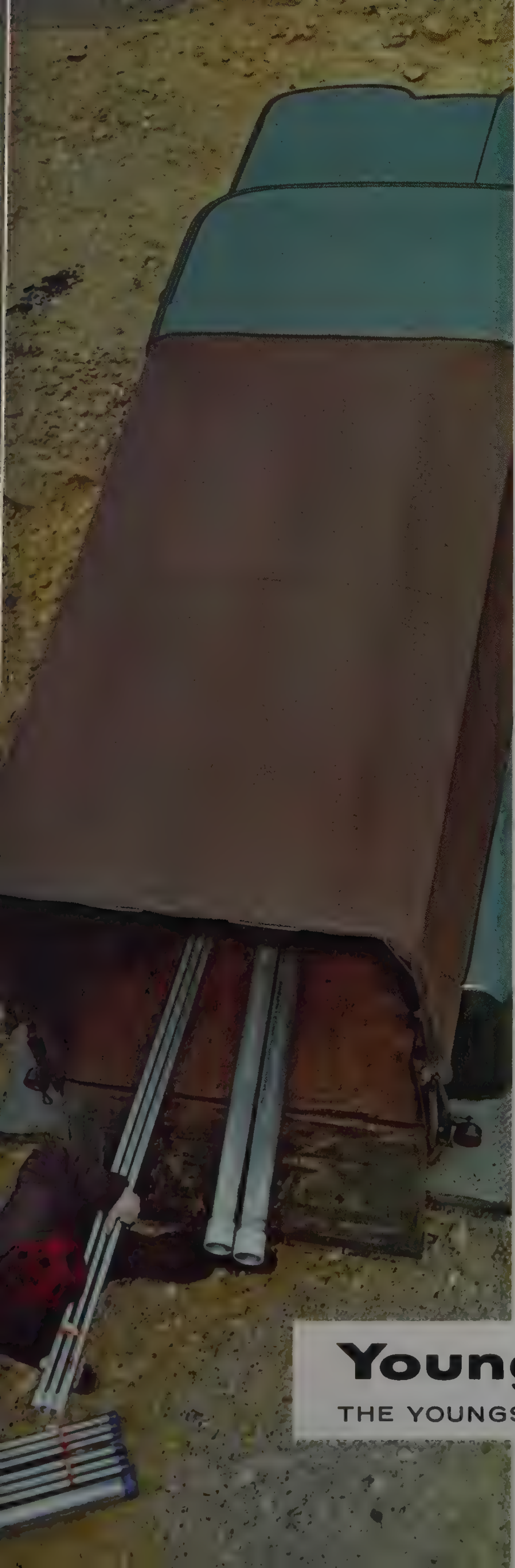
The company solved both problems at once by switching to Abolite fixtures equipped with 400 watt color-improved mercury lamps. The unit fixture cost was higher. But this was more than offset by the fact that only about half as many Abolite fixtures were needed. Maintenance costs are lower, too. Abolite's open-top fixtures stay cleaner than any other type industrial reflector. Lamp life is longer now—about 12,000 hours average with high lumen output maintained.

As you can see, the Abolite fixtures provide a high level of comfortable, glareless light throughout the room. Company officials credit the new system with increasing production and making working conditions safer.

With all these advantages, why settle for anything less than a cost-saving, light-improving mercury system with Abolite fixtures? Full information is yours for the asking. Just write:

ABOLITE Lighting

THE JONES METAL PRODUCTS COMPANY
West Lafayette, Ohio



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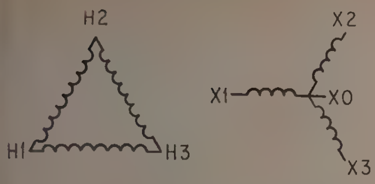
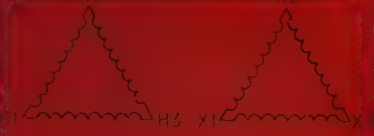
3-Phase Transformer Configurations



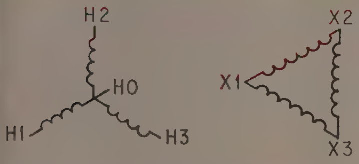
DELTA-WYE

Most commonly used to supply power and lighting loads fed by a 3-phase, 4-wire grounded neutral system.



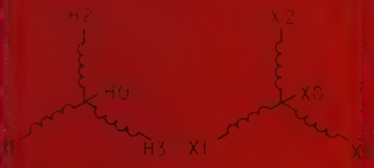
DELTA-DELTA

Used for transforming from one distribution voltage to another. Also used to supply delta utilization systems. [illegible]



WYE-DELTA

Used for stepping down voltages in power distribution



WYE-WYE

Has objectionable operating characteristics and is not [illegible]

WYE-WYE CONNECTIONS SHOULD BE AVOIDED

The use of wye-wye transformer connections is generally discouraged because of a number of objectionable characteristics associated with such connection. First, a connection of this type generally requires that the primary neutral point of the transformer windings be connected to the neutral of the source. Without connection of the primary neutral, unbalanced loading from phases to neutral on the secondary side produces a "floating neutral" on the primary side, with a serious unbalancing of secondary wye voltages and reduced power-handling capacity. And because the feeder neutral to the transformer primary is absolutely necessary to properly supply wye-connected loads on the wye secondary, the source from which the primary feeder originates must be provided with a neutral point. Of course, the foregoing objection to a wye-wye connection does not obtain for balanced wye or delta loading on the secondary.

The second, and major, objection to general use of wye-wye connected transformers arises from the character of harmonic currents generated in such a hookup. Under balanced conditions, a 3-phase system operates with a 120-degree phase difference between the phases of the fundamental current frequency and the phases of each harmonic frequency of current, except for the third harmonic and multiples of the third harmonic which are alternating in phase with each other. With sinusoidal applied voltage, magnetizing currents of iron-core transformers contain appreciable third harmonic current. But since the vector sum of currents at the neutral junction in a wye hookup must equal zero, third harmonic currents and multiples of third cannot exist in the primary of a wye-wye connected transformer if the primary neutral point does not have a connection to the neutral of the source supplying the transformer. Without the neutral connection, the third harmonic and multiples of third are eliminated.

When the third harmonic of the primary magnetizing current is eliminated by not connecting the primary neutral, the flux wave is distorted so that appreciable third harmonic voltage is induced in the secondary. In a wye-wye connection, these third harmonic voltages cancel each other between line terminals but they show up in voltages between line terminals and neutral. These harmonic voltage waves assume a phase relationship with the fundamental voltage wave such that the windings can be subjected to severe overvoltages. Voltage peaks of nearly twice normal amplitude can subject insulation to destructive magnetic stresses, even destroying the transformer.

There are two basic ways to eliminate the aforementioned effects due to wye-wye transformer connections. The simplest way is to provide a primary neutral to permit third harmonics in the transformer exciting currents, thereby producing sinusoidal flux and sinusoidal secondary voltages. This solution has the objection that the primary harmonic current flow may possibly produce interference on telephone lines. The second method of eliminating unsafe voltage stresses due to harmonic voltages is to use a tertiary winding in each transformer, in a delta connection. The delta tertiary windings short circuit the third harmonic voltages, producing the third harmonic of magnetizing current for sinusoidal flux. Thus, voltage spikes due to wave distortion are virtually eliminated.

The problem of third harmonics occurs in 3-phase, wye-wye hookups of single-phase transformers and in 3-phase transformers with shell-type construction of core and windings. However, wye-wye 3-phase transformers with core-type construction almost completely eliminate third harmonic flux and, therefore, do not produce an overvoltage operating condition and do not have third harmonic current.

For given conditions of application, a transformer manufacturer can provide the proper equipment for wye-wye transformation. However, careful attention to voltage levels and circuit design configuration—whether to use wye or delta connections—can often afford real economies by eliminating need for special provisions, such as tertiary windings, in transformers.

5. NOISE RATING—If a transformer used in a place of low ambient noise level—school, offices, etc.—it must have a low decibel hum rating and/or careful installation to prevent objectionable noise.

Air-cooled, dry-type transformers are generally enclosed in sheet-metal housings. The enclosure may or may not be ventilated. Completely enclosed units are made to permit use in atmospheres where dust, moisture, chemicals or other airborne matter might harm exposed coils in a ventilated case. Some units have their core laminations exposed to dissipate heat. Other small-size units have totally enclosed housings filled with epoxy compound which seals the windings against atmospheric attacks and greatly reduces operating hum.

Dry-type transformers are designed with different types of insulations on the windings to suit them to various applications:

Class "A" transformers, when properly loaded and applied in an ambient not over 40°C, will operate at no more than 55°C rise on the winding. Class "A" transformers are physically larger and heavier than corresponding sizes of Class "B" transformers.

Class "B" transformers, when properly loaded to rated kva and applied in an ambient not over 40°C, will operate at no more than 80°C rise on the winding. Class "B" units are about half the weight of Class "A" units.

Class "H" transformers, when properly loaded to rated kva and applied in an ambient not over 40°C, will operate at no more than 150°C rise on the winding. Such transformers use inorganic insulations impregnated with silicone compounds and varnishes to achieve the high temperature rating. Class "H" insulated transformers are generally smaller and lighter than those with other types of insulation.

WIRING DEVICES

Wiring devices include receptacles, switches, plates, and outlet boxes. Such devices are commonly used on all types of branch circuits. And sizes, ratings or types available provide a wide selection for most applications.

Receptacles

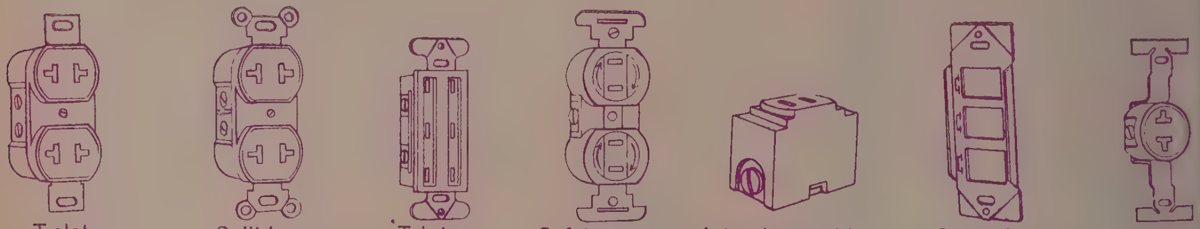
Receptacle ratings range from 10 to 400 amps with certain sizes available at 125, 250, 277, 480 and 600 volts.

Most popular, of course, are the 15- and 20-amp flush types, rated at 125 or 250 volts. These are available with several different slot configurations in grounding and nongrounding types. National Electrical Code rules require that receptacles installed for the attachment of portable cords shall be rated at not less than 15 amps, 125 volts or 10 amps, 250 volts. In addition, receptacles rated not more than 15 amps can be connected to 15-amp branch circuits serving two or more outlets. And 15- or 20-amp receptacles cannot be connected to multi-outlet branch circuits rated at more than 20 amps. For 30-amp and 50-amp multi-outlet branch circuits, use receptacles corresponding to the branch-circuit rating.

Another significant code rule states that receptacles connected to circuits having different voltages, frequencies or types of current (ac or dc) on the same premises shall be of such design that attachment plugs used on such circuits are not interchangeable. Quite frequently, receptacles will be installed in the same premises to serve 120- and 240-volt appliances. In such instances, receptacles with parallel blades are used for the 120-volt portables and receptacles with tandem blades would be required for the portable 240-volt equipment. And with corresponding attachment plugs provided for the portable equipment, plugging equipment into the correct voltage supply is assured. In some buildings, several different voltages or types or currents may be required for various portable attachments, in which case receptacles with different slot configurations would have to be selected for each source to prevent accidental interchange.

Grounding-type receptacles rated at 15 or 20 amps and installed in circuits of less than 150 volts between conductors must be approved for use only on potentials less than 150 volts. Grounding-type receptacles rated at 15 amps and installed in circuits of 151 to 300 volts between conductors shall be approved for use only on potentials not less than 151 volts. Present NEMA standards classify the 15- and 20-amp, parallel-blade, grounding-type receptacles at 125 volts and the 15-amp, tandem-blade, grounding-type receptacle at 250 volts. Following this standard simplifies the problem of a manufacturer to provide the proper attachment plug for common 120- or 240-volt portable appliances.

Presently under consideration by the National Electrical Code Committee is a provision that would require all receptacles connected to 15- or 20-amp branch circuits to be of the grounding types. Present 1959 code rules require grounding-type receptacles in the following areas of dwelling-type occupancies: (1) where installed in a kitchen at the sink location; (2) where installed in laundry rooms, open porches, breezeways, basements, cellars, work shops, garages, or out-



T-slot duplex

Split-bus duplex

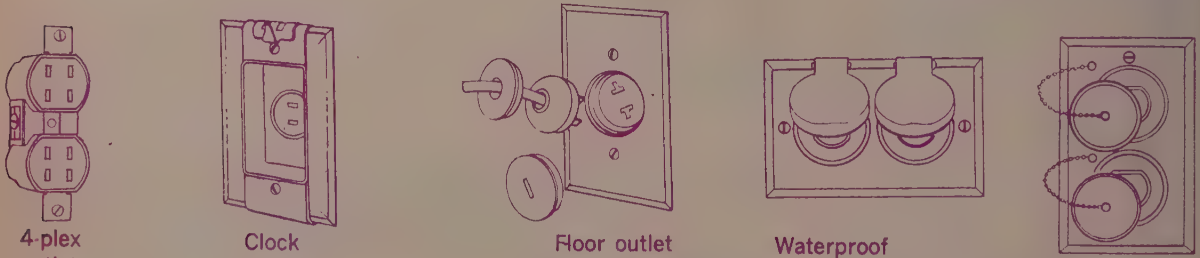
Triplex split bus

Safety-type duplex

Interchangeable plug

3-opening strap for interchangeable plugs

Single for special circuit



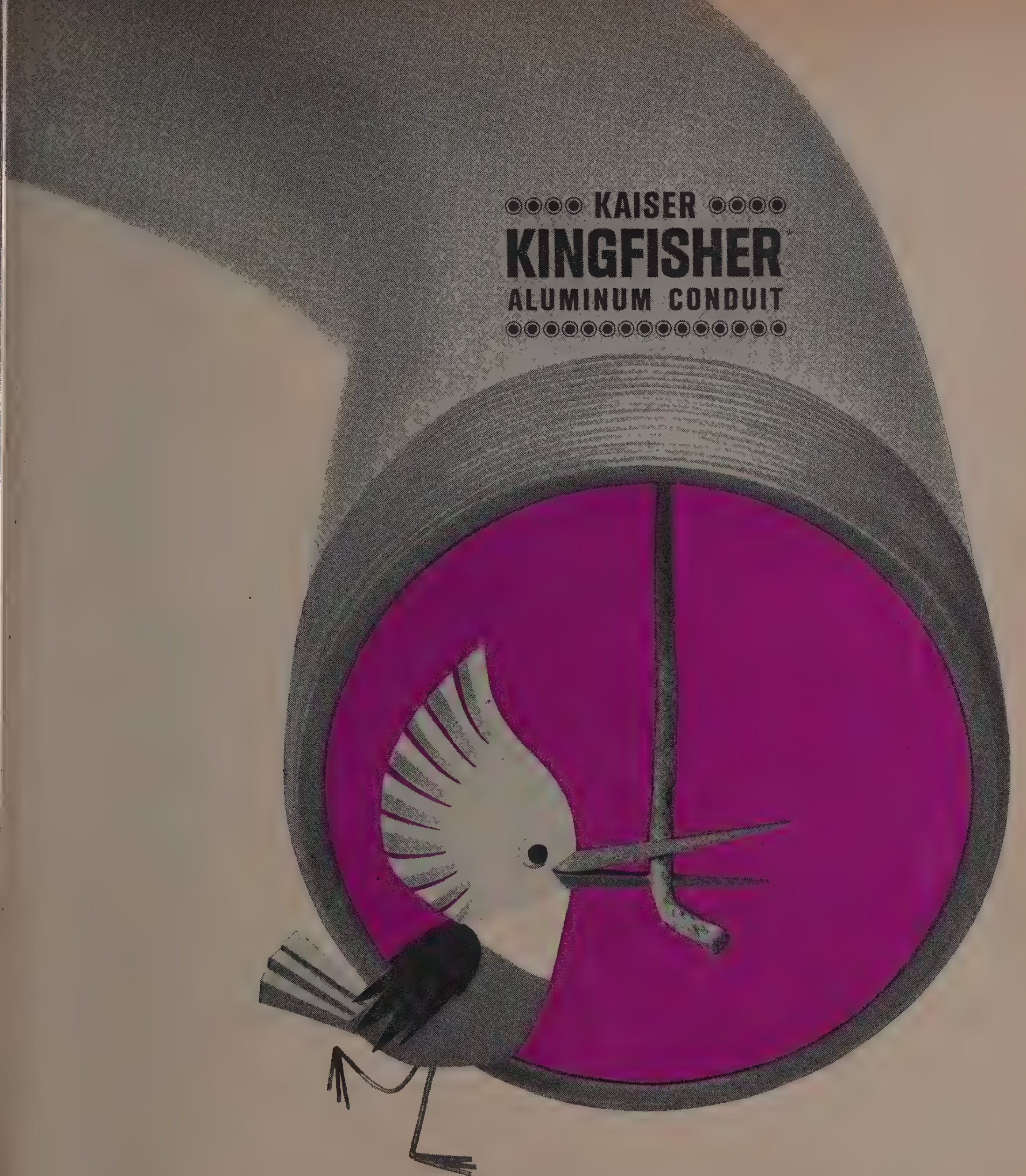
4-plex outlet

Clock outlet

Floor outlet & accessories

Waterproof outlets w/gr. type receptacles

TYPICAL FLUSH RECEPTACLES of the 125-volt, 15- or 20-amp parallel-blade types include single to 4-plex units and special purpose outlets for clocks, floors and outdoor applications. Three-opening straps will permit installation of interchangeable receptacles, switches, pilot lights, signal buttons and radio and TV outlets.



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†Using 3 #2RHW cables in 1¼" conduit.
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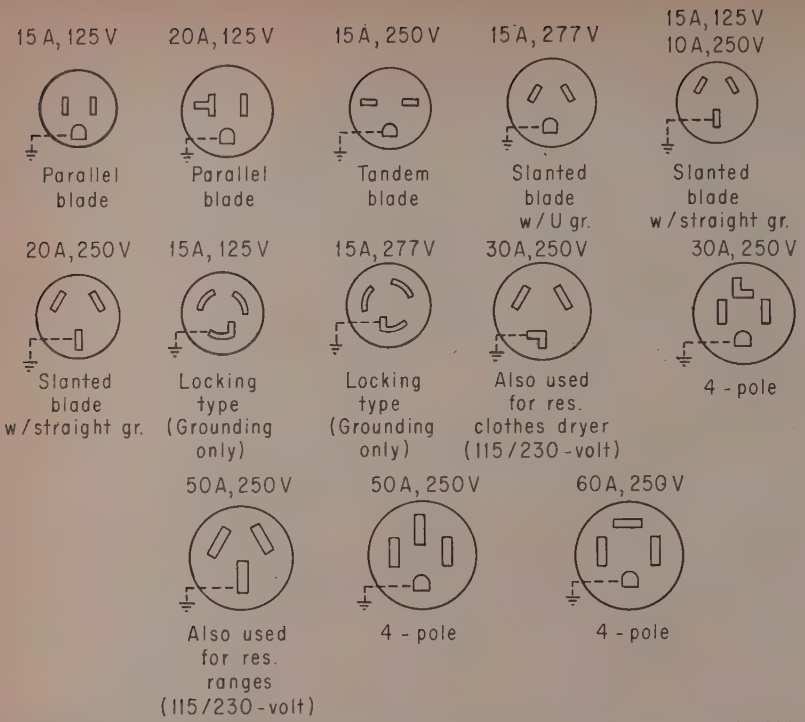


GROUNDING-TYPE RECEPTACLE slot configurations are shown for various NEMA classifications at different voltage and amperage ratings. Presently under consideration is a new code rule that would require receptacles installed on 15- or 20-amp branch circuits to be of the grounding types. Grounding-type receptacles are available up to 600-volt ratings.

doors where the outlet may supply equipment used by persons standing on the ground or on grounding conductive materials. In other type occupancies, grounding-type receptacles are generally required where portable appliances, required to be grounded, are installed.

Various slot configurations of grounding-type receptacles appear in an accompanying drawing, which shows common sizes from 15 amps to 60 amps in ratings of 125, 250 or 277 volts.

To conform to present NEC rules on grounding, receptacles used on circuits over 150 volts to ground would have to be of the grounding type. Three-pole grounding-type receptacles, rated at 15 amps, 277 volts are available for use on 2-wire 277-volt circuits derived from 480Y/277-volt systems. While only a few portable appliances are presently rated at 277 volts, more such equipment is to be expected in the future because of the common use of the 480Y/277-volt systems where large loads are encountered. The most common application of 277-volt receptacles, at present, is for connecting 277-volt fluorescent and mercury-vapor luminaires designed for cord attachment.

Terminals and Blades—In the 15- and 20-amp sizes, line terminals are available in screw types or spring-pressure types for wires of Nos. 14, 12 or 10. Depending on the back plate, the screw-type terminals receive bared conductors straight or looped. With the straight wire insert, the terminal plate has a groove for holding the wire in place when the screw is tightened. A flat terminal plate requires that the bared conductor be looped around the screw in a clockwise direction.

Spring-pressure terminals require no screws. After the wire is stripped, the bare end is pushed into a hole in the rear of the receptacle. Wire-gripping, spring-action terminals inside the receptacle hold the wires in place. Recessed wire wells prevent exposure of bare wire after the wire is inserted. Such terminals have a release slot to permit removal of conductors. Receptacles rated over 20 amps generally contain set-screw terminals.

Parallel-slot receptacles are generally classified as competitive, intermediate and specification grades. The specification-grade receptacles have more rugged components and construction, and are preferred over the lesser grades, especially on installations where a number of portable appliances will be used.

Split-Bus Receptacles—These are available in flush duplex or triplex types with ratings of 15 or 20 amps, 125 or 250 volts. Typical units consist of duplex assemblies with one parallel-blade receptacle (125 volt) and one tandem-blade receptacle (250 volt); or two parallel-blade receptacles. Split-bus triplex receptacles are the parallel-blade type for use on 120-volt circuits. All forms of split-bus receptacles make it possible to wire separate circuits or control to each set of line terminals. Accompanying drawings indicate a variety of these receptacles.

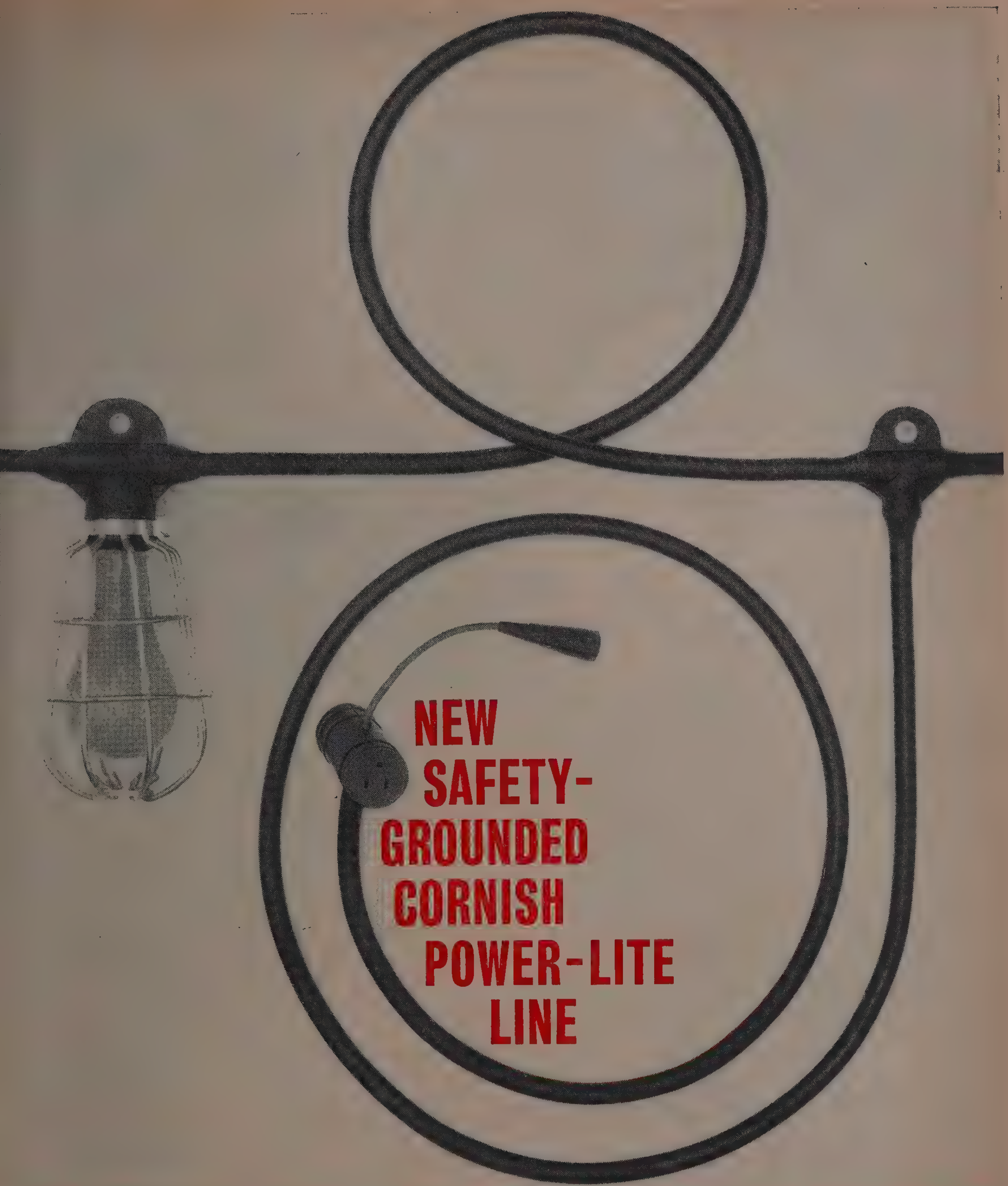
Many standard parallel-blade duplex receptacles contain a "break-off" feature, which makes it possible to use both receptacle openings on a single circuit as in most instances; or, if split-bus arrangement is desired, a jumper can be removed on the line terminal bus to provide for 2-circuit operation. Another form of split-bus construction is with the use of receptacles of the interchangeable line where two or three receptacles can be attached to the same strap, and separate circuits or control can be supplied to each receptacle.

Locking-type receptacles are available for applications where it is important that the cord attachment caps cannot be pulled out.

Flush or surface receptacles are made in 3- or 4-pole types with ratings of 30, 50 or 60 amps. Three-pole 30- and 50-amp receptacles are commonly used for residential electric dryers and ranges where the grounded neutral of 115/230 circuits can be used to ground such appliances. In some areas, using the neutral as an equipment ground is prohibited by local ordinance. Such areas require 4-pole 30- or 50-amp receptacles, where one slot is used exclusively for a grounding conductor. Four-pole 60-amp (250-volt) receptacles are designed for commercial and industrial applications to supply 3-phase or 115/230-volt equipment.

Because of varying physical dimensions, outlet boxes for the flush 30- or 50-amp receptacles should be sized according to the manufacturer's recommendations. Surface receptacle-outlet assemblies in these sizes are available in metallic or non-metallic enclosures. The metal enclosure is recommended where the unit will be subject to mechanical injury.

Heavy-Duty Receptacles — For



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use in industrial plants or for some commercial establishments, heavy-duty receptacles are mounted in integral cast-metal assemblies. Combination units of this type have conduit hubs and receptacle sizes ranging up to 400 amps at 250 volts and 200 amps at 600 volts. The enclosures are available in general purpose or raintight types. Other receptacle and enclosure assemblies are designed for use in corrosive or hazardous locations with a wide variety of such equipment made for practically any purpose.

Miscellaneous Receptacles—Additional types of receptacle outlets include those for wall clocks, floor installation, multi-outlet assemblies, motor plug-base assemblies, outdoor applications, and radio and TV plug-in units.

Switches

By NEC reference, small-capacity control switches up to 30 amps and 600 volts are classified as snap switches although they are generally known as tumbler, toggle, mercury, and butt-contact (quiet) types.

Article 100 of the NEC gives the following definitions of snap switches:

"General Use Snap Switch. A form of general use switch so constructed that it can be installed in flush device boxes, or on outlet box covers, or elsewhere used in conjunction with wiring systems recognized by this Code.

"AC General Use Snap Switch. A form of general use switch suitable only for use on alternating-current circuits for controlling the following:

"(a) Resistive and inductive loads (including electric discharge lamps) not exceeding the ampere rating at the voltage involved.

"(b) Tungsten filament lamp loads not exceeding the ampere rating at 120 volts.

"(c) Motor loads not exceeding 80% of the ampere rating of the switches at the rated voltage.

"All ac general use snap switches are marked 'ac' in addition to their electrical rating.

"AC-DC General Use Snap Switch. A form of general use snap switch suitable for use on either direct- or alternating-current circuits for controlling the following:

"(a) Resistive loads not exceeding the ampere rating at the voltage involved.

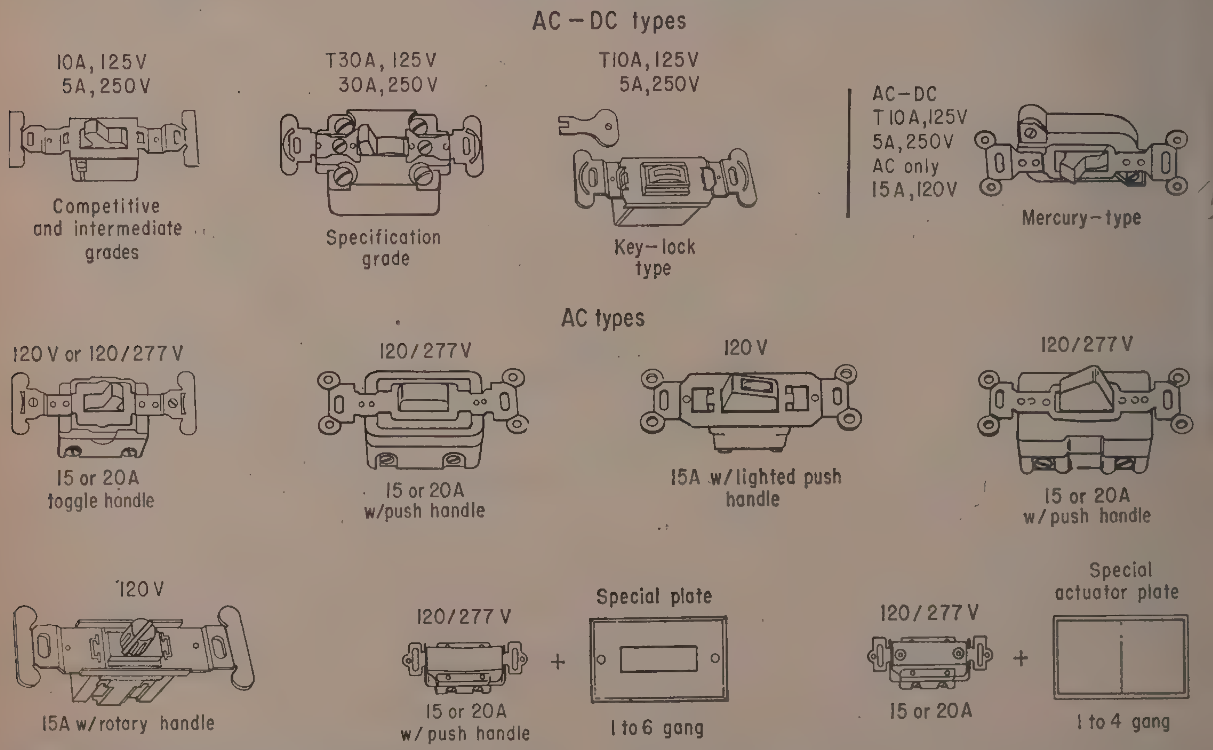
"(b) Inductive loads not exceeding one-half the ampere rating at the voltage involved, except that switches having a marked horsepower rating are suitable for controlling motors not exceeding the horsepower rating at the voltage involved.

"(c) Tungsten filament lamp loads not exceeding the ampere rating at 125 volts, when marked with the letter 'T.'

"AC-DC general use switches are not generally marked ac-dc, but are always marked with their electrical rating."

Underwriters' Laboratories, Inc., follow these code definitions in classifying snap switches and setting up testing standards.

In the switches presently available, the ac snap switches are rated 15 or 20 amps at 120 or 120/277 volts. All such switches are clearly marked "ac only" with their respective ampere and voltage rating. It is significant that the ac snap switches are of the silver-to-silver butt-contact types, commonly referred to as quiet-type switches. As a result, the ac snap switches can comply with more rigid UL tests than the blade-or wiping-type tumbler switches classified as ac-dc types. While ac snap switches have specific advantages in ratings over



GENERAL USE snap switches are classified as ac or ac-dc types. Shown are a few of both types. AC snap switches come in a wide variety of styles, and their silver-alloyed contacts offer long life, quiet operation and finger-touch control. Unique switch styling blends with modern architectural decor and attractive device plates.

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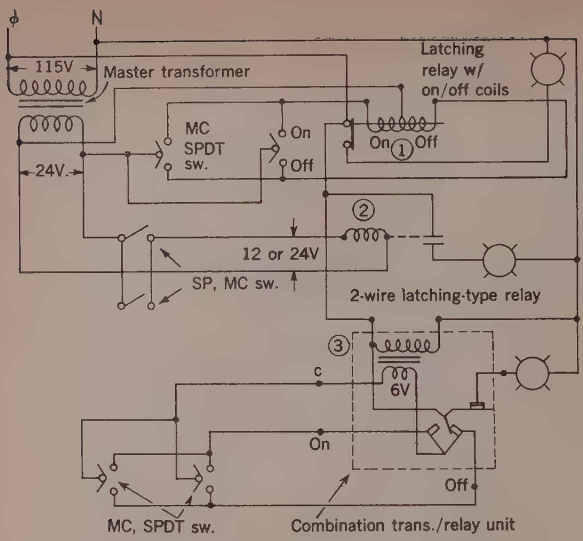

LOW - VOLTAGE relay switching systems are available in three types. Any of the systems shown can be adopted to full master control hookups and pilot-light indication with proper auxiliary equipment. Systems (1) and (2), with solenoid-type relays, can be used with optional rectifier units to eliminate ac hum. System (3) uses a thermal - element relay and has a built-in transformer in each unit.

ac-dc snap switches, they can only be used on ac circuits. A notable exception to this is the mercury switch.

Mercury switches have an ac rating of 120 volts, 15 amps, but they are also T-rated at 10 amps, 125 volts dc. A major limitation to mercury switches is that they cannot be installed horizontally.

Flush snap switches are available in the following types: (1) single-pole; (2) double-pole; (3) 3-way; (4) 4-way; (5) 2-circuit; (6) maintained contact, SPDT, DPDT; and (7) momentary contact, SPDT, DPDT, SP normally open, SP normally closed, DP normally open and DP normally lcosed, and 3-way. Most of these switches can be obtained with key-lock design, and ratings vary among the manufacturers.

Some ac snap switches can be obtained with internal line shunts to simplify the installation of jumpers between switches in the same box. Another type has an internal shunt for making a neutral connection where this conductor passes through the switch box as in typical cable installations. For both types, the connections are generally the screwless, spring-pressure terminals.

With the wide use of fluorescent lighting on alternating-current systems, it is obvious that ac snap switches have a decided advantage over ac-dc switches, particularly on circuits where switches control the bulk of the branch-circuit load. In such instances, a 15-amp ac snap switch equals two 15-amp ac-dc snap switches, because on inductive loads, the former can be loaded to 100% of its rating, while the latter must not exceed 50% of its rating.

For tungsten-filament lamp loads or for combined tungsten-filament and non-inductive loads, ac snap switches may be used at their full rating on ac systems. However, ac-dc switches used for such loads must be "T" rated on either ac or dc systems according to the NEC with certain exceptions, which state: "A switch that is not 'T' rated may be installed to control such loads provided all three of the following qualifications are satisfied—(1) Where switches are used in branch-circuit wiring systems in private homes; in rooms in multiple-occupancy dwellings used only as living quarters by tenants; in private hospital or hotel rooms; or in similar locations but not in public rooms or places of assembly; and (2) Only where such a switch connects permanently connected fixtures or lighting outlets in one room only, or in one continuous hallway where the lighting fixtures may be located at different levels, or on porches or in attics or basements not used for assembly purposes; and (3) The switch is rated at not less than 10 amps, 125 volts; 5 amps, 250 volts; or for the 4-way types, 5 amps, 125 volts, 2 amps, 250 volts."

Another advantage of ac snap switches is that the type of switching mechanism permits the use of handles that differ from the long-established toggle types. As a result, many modern "pushbutton" or "touch" type switches are available; and the many styles offered by manufacturers provide a good selection for varying decors.

Line terminals are essentially th same as previously described f receptacles. And weatherproof en closures and covers are availab for most snap switches. Moreove many switch enclosures are mac for corrosive and hazardous loca tions.

Various makes of snap switche can be obtained where miniaturize neon lamps are built into the ope ating handles, thereby providin pilot-light operations.

Low-Voltage Control—Low-vol age relay switching offers a prac tical and economical solution fo wiring installations involving number of sets of multiple switc control. This is particularly tru when the general wiring in a buil ing is in raceways. Except in haz ardous locations, Class II, low-vol age remote-control wiring need no be installed in raceways. Thre types of low-voltage relay-contro systems are shown in an accom panying drawing.

Miscellaneous Switches — Othe types of switch control include cei ing pull switches, surface tumble switches, canopy switches, photo cell switches and feed-through cor switches.

Interchangeable Line

The interchangeable line make it possible to provide a compac group of switches, receptacles, pilot lights or pushbuttons. In general each strap will handle three interchangeable devices. Thus a 2-gan switch box could contain six interchangeable devices, three per stra A good stock of interchangeable devices enables a contractor to set u wiring devices according to an custom need.

Very similar to the interchangeable line are combination device which provide two switches, switch and receptacle, a switch an pilot light, or similar arrangements. These units are integra assemblies and are provided wit separate or common terminals a desired.

Device Plates

About any combination of devic plates are available for groups o switches, receptacles and simila equipment. Such plates or cover are made of bakelite, plastic, stee enameled metal, brass, glass an other materials for special uses.

NEC rules covering plates fo

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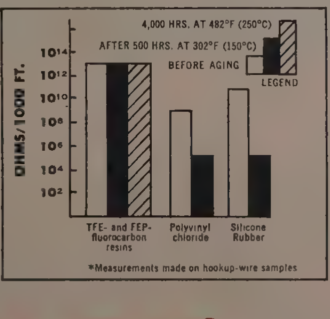

*Measurements made on hookup-wire samples

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Number of Conductors in Boxes

Box Dimensions, Inches Trade Size	100% Cu In. Capacity	Maximum Number of Conduct			
		No. 14	No. 12	No. 10	No
1½ x 3¼ octagonal	10.6	5	5	4	0
1½ x 4 octagonal	16.5	8	7	6	5
2⅛ x 4 octagonal	23.0	11	10	8	6
1¼ x 4 square	17.6	9	7	6	4
1½ x 4 square	21.1	11	9	7	5
2⅛ x 4 square	29.9	16	12	10	8
1½ x 4 11/16 square	30.0	16	12	10	8
2⅛ x 4 11/16 square	42.0	20	16	12	10
2 x 2 x 3 device box	10.2	5	4	4	0
2¼ x 2 x 3 device box (beveled)	10.8	5	4	4	0
2½ x 2 x 3 device box	12.8	6	6	5	0
2¾ x 2 x 3 device box	14.2	7	7	6	0
3½ x 2 x 3 device box	18.0	9	8	7	0
1½ x 2⅛ x 4 utility box	11.0	5	4	4	0
1⅞ x 2⅛ x 4 utility box	14.0	7	6	5	0
2⅛ x 2⅛ x 4 utility box	16.0	8	7	6	0
2 x 4 octagonal concrete box	25.0	12	11	9	7
2½ x 4 octagonal concrete box	31.0	16	12	10	8
3 x 4 octagonal concrete box	37.0	18	15	11	9
*3½ x 4 octagonal concrete box	43.0	20	16	12	10
4 x 4 octagonal concrete box	49.0	22	17	13	11
5 x 4 octagonal concrete box	62.0	26	20	15	13
6 x 4 octagonal concrete box	74.0	30	23	17	15

* Same dimensions as a 4-in. octagon hung-ceiling box 3½-in. deep. Where there is not sufficie space for a deeper box, four No. 14 Awg conductors may enter a box provided with cable clam

TABLE SHOWS the number of conductors permitted in several popular box siz not listed in the NEC in addition to those that are listed. For each box size th cu in. capacities given are representative values. Each wire running through a bo (without connection) counts as one wire. Each wire entering and connected in a bo counts as one wire. Fixture wires or jumpers within a box need not be counte Deduct one wire from table where one or more fixture studs, cable clamps o hickeys are contained in a box. Deduct one wire for one or more flush devic mounted on the same strap. For wire combinations not shown in table: N 14 = 2 cu in., No. 12 = 2.25 cu in., No. 10 = 2.5 cu in., and No. 8 = 3 cu i

switches and receptacles require that faceplates of non-ferrous metal shall be not less than 0.040 in. thick, and for ferrous metal, not less than 0.030 in. thick. And non-metallic plates must be of non-combustible material and not less than 0.10 in. thick.

While most switches and receptacles are available in ivory or brown types, other colors can be obtained to match special plate colors such as gold, red, beige, black, white, yellow, blue or green. Also various decorative plates are made, some of which are designed for specially styled switches.

Outlet and Device Boxes

As discussed here, outlet and device boxes include sheet-metal and non-metallic types commonly used with interior wiring systems for the attachment of lighting fixtures, switches or receptacles.

Metallic boxes are generally of the sheet-steel types, with galvanizing or similar protective coatings, and the size of the metal is No. 14 USS gauge (0.0747 in. thick).

Boxes constructed of sheet aluminum are still not available on a large scale, due mainly to higher costs than steel boxes and the successful field experience of standard steel boxes with aluminum conduits and fittings.

Non-metallic boxes are constructed of bakelite, plastic, fiberglass or porcelain material and they can only be used with non-metallic wiring methods. Using non-metallic boxes with non-metallic wiring methods and insulated plates or covers can provide a completely insulated wiring system such as used in many corrosive or damp locations. In such instances, grounding is minimized and the non-metallic components are not adversely affected by these environmental conditions.

Other than the porcelain types, present-day non-metallic boxes are more durable than those available in past years. New developments in plastics and similar materials have made it possible to produce boxes that can withstand the normal physical abuses found on most construction jobs. On the other hand, porcelain boxes break easily and should not be used where subject to mechanical injury during or after construction.

While it is quite natural that steel boxes are of more durable construction than non-metallic boxes, the chief advantages of the metal types are that they can be used with most wiring methods, and they are available in a wide range of sizes and types.

In many of the popular sizes, boxes are provided with clamps suitable for securing non-metallic sheathed cable, non-metallic flexible tubing (loom) or armored cable. Clamps for such purposes are marked "N" for non-metallic sheathed cable, "T" for non-metallic flexible tubing, and "A" for metal armored cable. Many clamps are marked "NT" for use with both previously mentioned non-metallic systems. Clamps for non-metallic systems are located inside of boxes. For armored cable systems, clamps are either inside or outside of the boxes. Obviously, the external clamps permit more wiring space inside the box.

For most cable jobs it is generally more economical to use boxes provided with clamps than to use conduit boxes with separate cable connectors.

In selecting box sizes for any type of wiring method, the main con sideration concerns the number o conductors that will be installed i the box together with switches o receptacles, studs or clamps.

Section 370-6 of the NEC includes tables for deep and shallo boxes, which determine the size o several popular boxes according t the number of conductors, device and fittings within them. However Table 370-6 (a-1) does not includ such common boxes as utility boxe or concrete boxes, nor does it include the cu in. capacity of boxe to simplify the calculation of bo sizes where conductors of differen sizes are encountered. To simplif such a procedure, an accompanying table is included, which can b used as a guide to determine bo sizes quickly. The cu in. capacitie given are based on average value and on free wiring space (withou conductors, devices or fittings) Moreover, the table is based on th cu in. values for conductors of No 14 to 8 as given in Table 370-6 (b)

The accompanying table shoul be applied the same as Table 370- (a-1) in the NEC.

CONNECTORS

As included in this section, wire onnectors apply to all types of de- ices intended to join or terminate lectrical conductors. Cable con- ectors refer to fittings designed to ecure metallic or non-metallic ables to enclosures such as cabi- ets and outlet boxes.

Wire Connectors

Since every electrical installation ontains numerous splices and erminations, the selection of proper vire connectors for various sizes, ombinations and types of conduc- ors is an extremely important actor in a sound electrical installa- ion.

Wire connectors are generally lassified as either thermal or pres- ure types.

Thermal connectors include those n which heat is applied to form oldered, brazed or welded joints nd terminals. Soldered joints and ugs for copper conductors have een used for many years and, ex- ept for service wire and ground onnections, are still permitted. Iowever, soldering is rarely used in nodern installations because of the reater dependability and installa- ion ease of present-day solderless ressure connectors. And while it s possible to solder aluminum con- uctors, this is not recommended nless the installer is fully familiar with the special techniques involved. On the other hand, welded aluminum connections in circular-mil sizes are very satisfactory and provide the best possible joint for aluminum conductors. At the same time, this process is generally restricted to the types of installations in which the cost of the necessary equipment and skilled labor can be justified.

Grounding grids or bussing are widely used on large construction jobs and grounding connections must be permanent in the interests of safety. For joining bare copper conductors together or to reinforcing rods, ground rods or steel surfaces, a mold-type welding process is highly recommended. This process consists of a mold and starting and mixing powder. After conductors, sleeves and/or lugs are placed in the mold a flint gun is used to ignite the starting powder. This forms a liquid copper, which fuses conductors into a solid mass and welds a permanent electrical connection. Offered by several manufacturers, the mold-type welding process can be performed easily without special training.

A solderless pressure connector is a device which establishes the connection between two or more conductors or between one or more conductors and a terminal by means of mechanical pressure and without the use of solder. This broad NEC definition includes the bulk of solderless connectors and terminal lugs.

The common screw-on pigtail connector consists of an insulated cap made of plastic, bakelite, porcelain, or nylon and an internal threaded core with or without a metallic coil spring. Such connectors require no hand tools and are simply twisted onto appropriate combinations of bared conductors. Connector types consisting of metallic spring coils (copper coated or steel) are listed by UL as pressure cable connectors, which means they can be used for connecting branch-circuit conductors No. 14 and larger according to listed sizes and combinations; and in certain instances, these connectors can also be used as fixture-splicing connectors in which case they will be dual-listed by UL.

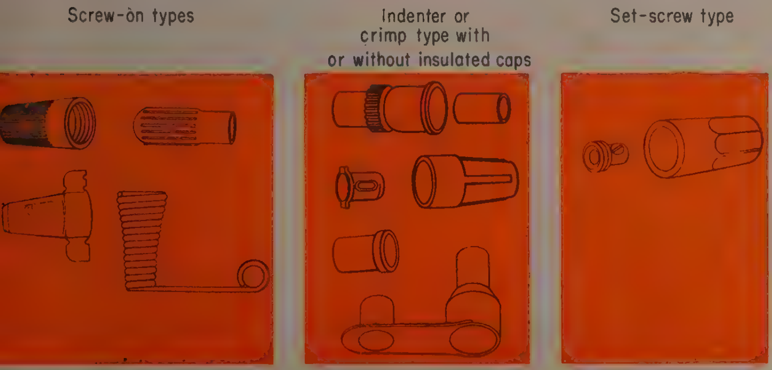
On the other hand, the connectors without metallic coil springs are regarded as fixture-type splicing connectors for joining fixture wires or branch-circuit wires to fixture wires in a combination of sizes from No. 18 to No. 10 within the listed capacities of the connector. They are not acceptable for general use in branch-circuit wiring.

Most of the screw-on connectors are designed for copper-to-copper wire connections. An exception is the type with a coated-steel coil spring, which has UL listing for aluminum-to-aluminum wire connections as well as copper-to-copper connections. However, no pressure connector, including the screw-on type, is approved or recommended for splicing aluminum and copper conductors together where the two different metals are in direct physical contact with each other.

With screw-on-type connectors, solid conductors are inserted parallel into the connector. Then the connector is twisted, thus forming a locking action on the conductors, and providing a dependable connection. Stranded wires in the smaller sizes are twisted together before installing the connector. And in all cases, proper size connectors should be selected to accommodate the size and combination of conductors involved in each splice.

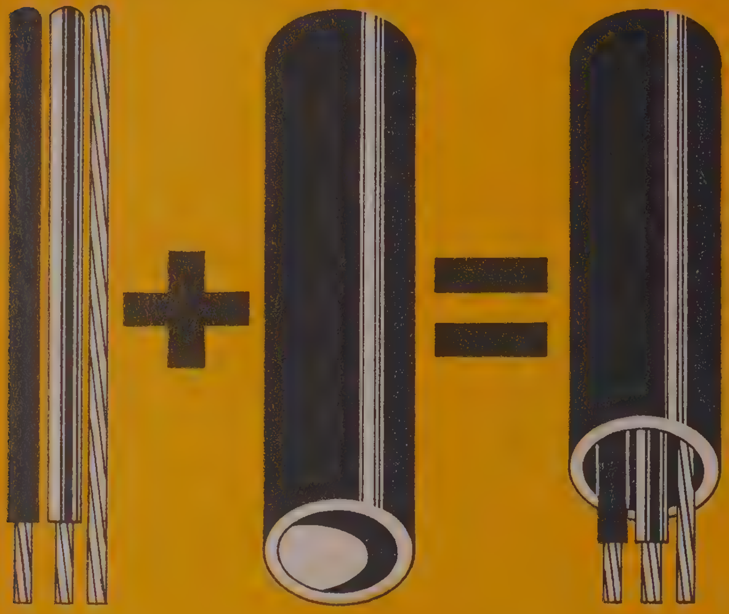
Maximum voltage ratings for screw-on connectors are 600 volts (or 1000 volts inside a fixture or sign), although some types cannot be used on circuits over 300 volts. Also, temperature ratings will vary

Typical Solderless Pigtail Connectors



OLDERLESS CONNECTORS for pigtail splices of smaller conductor sizes are avail- ble in the form of screw-on, indenter or crimp, and set-screw types, with or without nsulating caps.

TRIANGLE UNIT TYPE DUCT-CABLE SYSTEM



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according to the type of insulating cap. Data for voltage and temperature ratings of the various connectors can be obtained from the individual manufacturer's catalog.

Bolted-type pressure connectors include those for making pigtail, straight, tee, or terminal connections. Such connectors depend on the applied force of bolts or screws to produce the clamping and contact pressures between conductors and the connector.

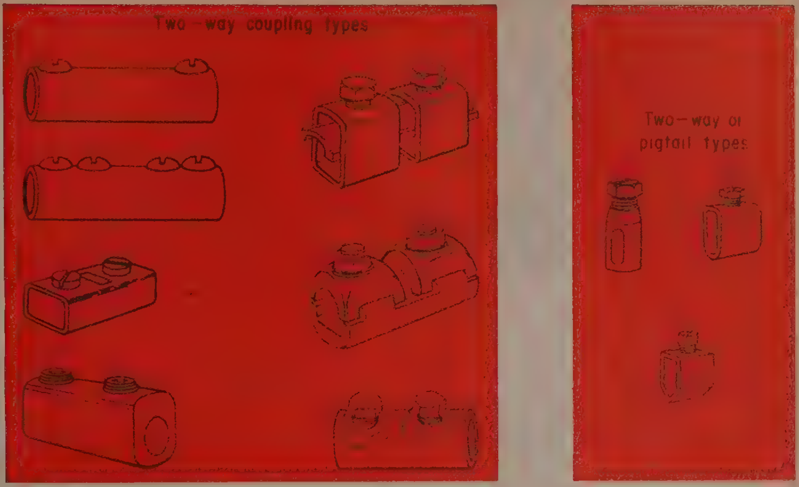
For making pigtail connections in wire combinations up to No. 10, set-screw connectors with a separate insulated cap, which threads onto the connector after securing the wires, are readily available. These connectors are used in branch-circuit wiring, fixture hanging, and equipment hookups. The only tool required is a screwdriver, and the connectors can be re-used. As such, they are especially recommended in installations where wiring connections will be changed frequently. Various set-screw connectors with thread-on insulated caps are UL listed as pressure wire connectors and/or fixture-splicing connectors according to individual manufacturer's listings.

Other types of bolted connectors are available for practically any desired wire combinations, sizes or arrangements. Accompanying drawings show a variety of such devices. Such connectors are constructed of copper, bronze or alloys of similar metals for use with copper conductors. Connectors for joining aluminum wires together are constructed of aluminum, tin-plated silicon bronze or tin-plated copper alloy materials.

Where copper conductors will be connected to aluminum conductors, connectors should be selected which are designed for this purpose, and which provide bi-metal or tinned spacers. The bi-metal or tinned spacers permit separation of aluminum and copper conductors, thus preventing the possibility of galvanic corrosion. Careful compliance with manufacturers' recommendations as to cleaning aluminum conductors, applying connector aids, and properly positioning the aluminum and copper conductors will provide a satisfactory joint.

Many forms of bolted connectors are designed for making branch connections from main conductors. In such instances, minimum and maximum wire sizes are listed for both main and branch (tap) ranges.

Straight Coupling-Type Solderless Pressure Connectors



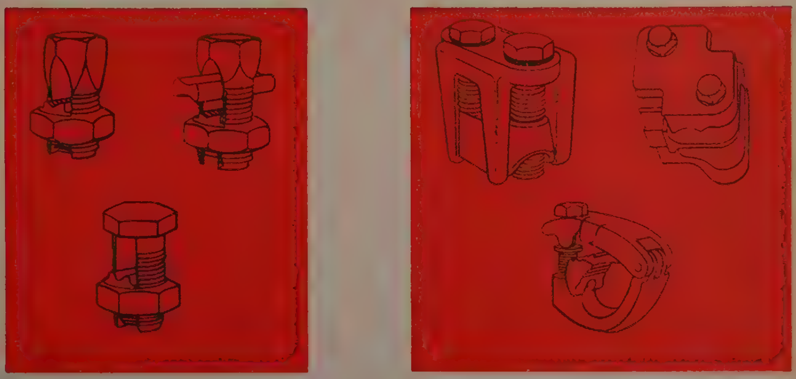
TWO-WAY CONNECTORS are designed for making straight coupling splices of conductors. The types shown are typical of bolted types. Connectors shown at right are also used for pigtail connections.

Such ranges in wire sizes are listed for each connector, and for satisfactory connections, should be carefully observed. Split-bolt, clamp-type, gutter-tap and parallel cable-tap connectors are a few of the common types used for splicing branch conductors to main conductors. Except for the parallel cable-tap connectors, these connectors must be taped after the wires have been connected. Some parallel cable tap connectors feature a two-piece molded-plastic cover that fits over the connector and covers uninsulated parts. This eliminates the time required for taping, and makes it possible to remove the connector quickly if this is a factor to be considered.

Wires are fastened to bolted-type lugs by one or more bolts, depending on design and ampere ratings. Two- to four-barrel lugs are used to terminate multiple conductors.

Where numerous connections are necessary, as in complex control circuitry, consideration should be given to the use of terminal blocks and terminal block kits made available by a number of manufacturers. Such assemblies contain bolted-type terminal blocks. The terminal blocks can be obtained in fully assembled or individual blocks, and the terminals are available for a wide range of wire sizes. With these units, connections can be made quickly and all terminals can be readily identified, thus simplifying troubleshooting or later changes in circuitry. And the terminal blocks can be installed in standard pull boxes or auxiliary gutters.

Run and Tap Solderless Pressure Connectors


Split-bolt type

Clamp-type

RUN AND TAP connectors are designed to permit branch taps from main conductors. Drawing shows a few of the split-bolt and clamp-type solderless connectors.

Touchette®

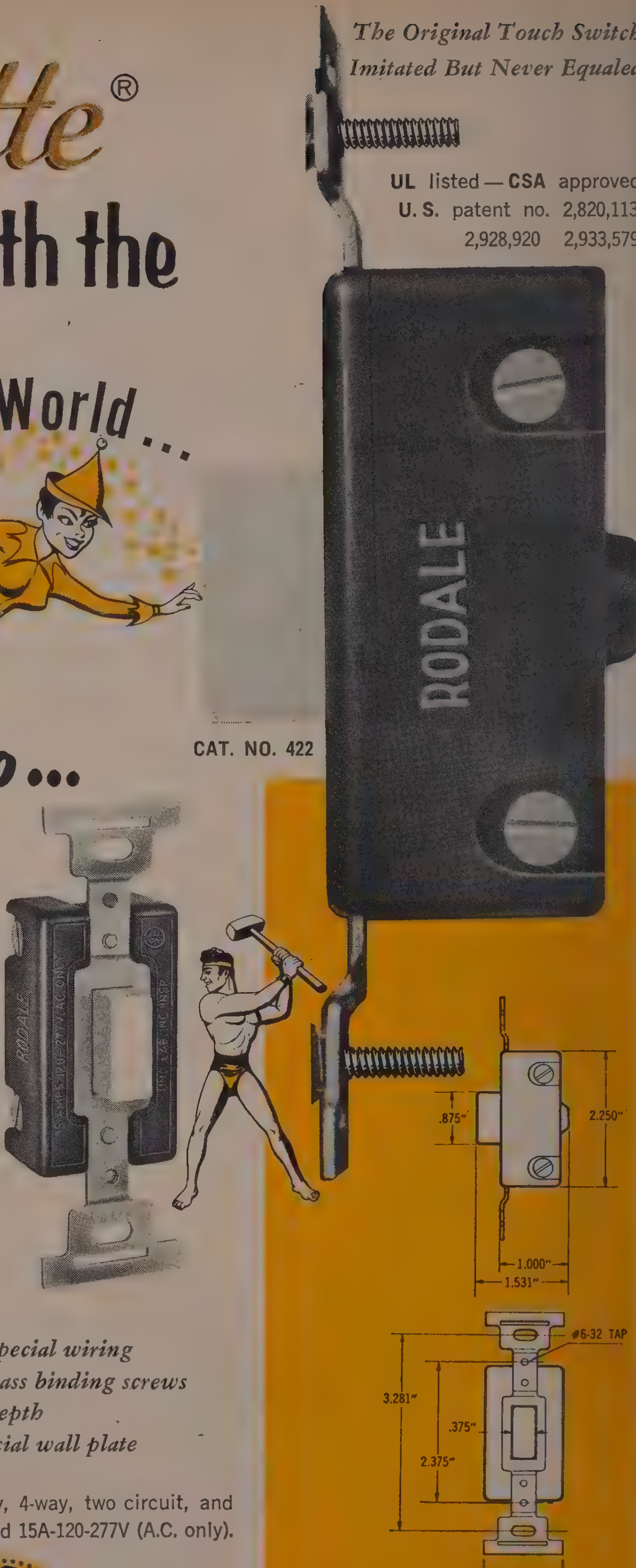
still the switch with the

Softest Touch in the World...

and most rugged too...

The Original Touch Switch Imitated But Never Equaled

UL listed — **CSA** approved
U. S. patent no. 2,820,113
2,928,920 2,933,579



Touchette the most Sensitive Touch Action Switch available. To test the validity of this claim, take a Rodale Touchette and any other touch switch . . . press them together button to button. At the slightest pressure, Touchette switches on. Greatly increased pressure is required to actuate the other switch. Remember, Rodale has been making this type of touch switch longer than anyone else.

Touchette ...is Ideal, for

- *New Construction*
- *Rewiring*
- *Replacing*
- *Remodeling*
- *Least expensive touch switch*

WHY?

- *Most rugged — yet easiest touch*
- *Quickly installed*
- *Mounting screws in place*
- *Fits standard outlet boxes*
- *Requires no special wiring*
- *Large head brass binding screws*
- *Is but 1" in depth*
- *Needs no special wall plate*

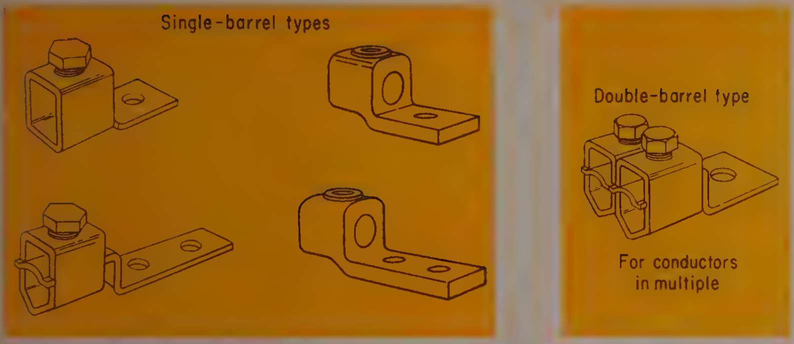
Touchette is available in single pole, double pole, 3-way, 4-way, two circuit, and 20 AMP Models. Brown, Ivory or White touch button. Is rated 15A-120-277V (A.C. only).

Ask about two-circuit Touchette for light dimming applications (CAT. NO. 462)

Sold only through electrical wholesalers, or for further information and prices, write Rodale direct.

Rodale manufacturing co., inc.
emmaus, pa.

Bolt-Type Terminal Lugs



BOLT-TYPE TERMINAL connectors are classified as single-, two- or three-barrel types, and the lug surface contains one or more holes depending on ratings and designs. Representative types are shown.

Compression-type connectors and lugs include those in which hand, pneumatic or hydraulic tools indent or crimp tubelike sleeves which hold the one or more conductors. The crimping action changes the size and shape of the connector; and a properly crimped joint deforms the conductor strands enough to provide good electrical conductivity and mechanical strength. With the smaller sizes of solid wires, some indenter splice caps require that the wires be twisted together before being placed in the cap and crimped, while others are intended to be inserted parallel. This will vary with the type of indentations, and the manufacturer's recommendations on the correct method of making the splice should be followed.

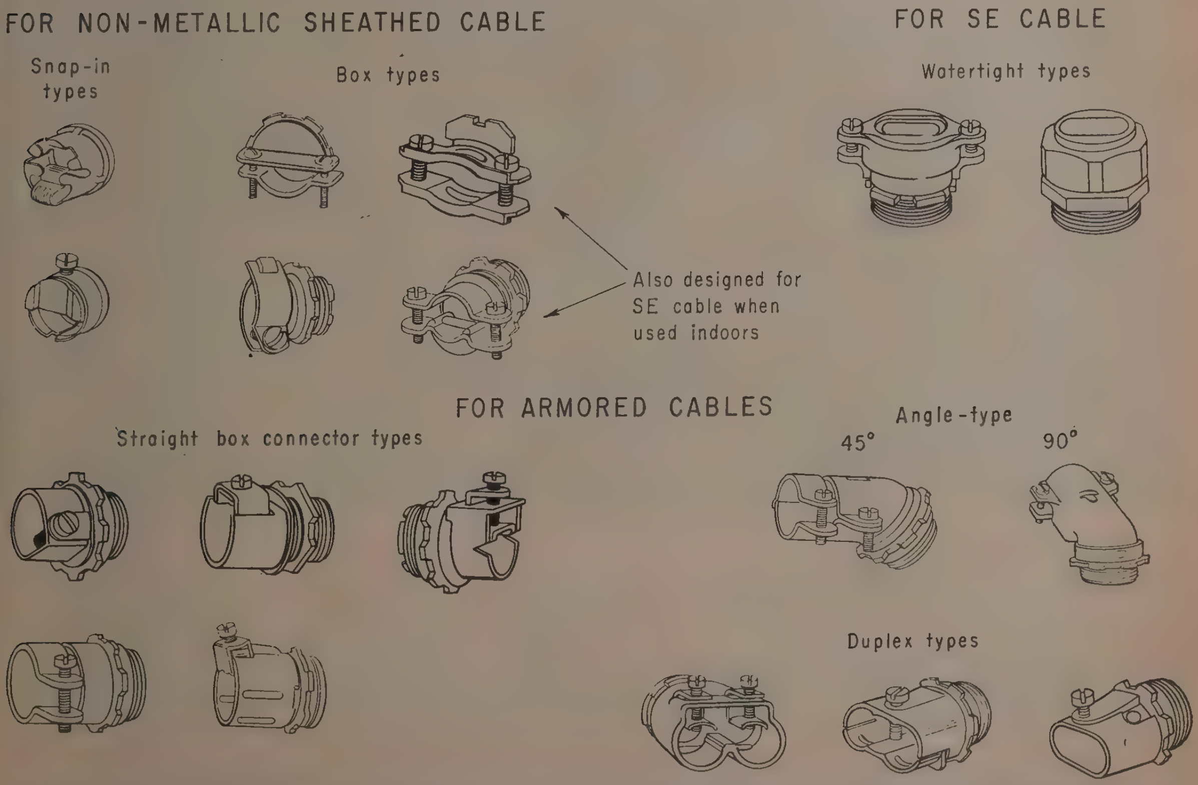
One of the disadvantages of indenter or crimp connectors is that special tools are required to make the joint. However, many contractors feel that this can be justified by the assurance of a dependable joint and low cost of connectors.

Connectors are designed for either copper or aluminum conductors, or both. Connectors with no markings are generally suitable for copper conductors only. Where a connector bears the marking "AL," it is designed solely for the connection of aluminum conductors. And connectors marked "CU-AL" are for use with either copper or aluminum conductors.

Straight coupling connectors, marked "CU-AL" are ideal where aluminum conductors are run to equipment with terminals designed for copper conductors. In such cases, a short piece of copper wire extends from the equipment terminals to one side of the straight coupling connector; and the aluminum conductor is connected to the opposite side. On the other hand, terminals in many new meter sockets, switches and panelboards are designed for connection to either copper or aluminum wires. If this is the case, a statement to that effect will appear on the inside of the enclosure, and no markings will be found on the terminals.

All connectors designed for connecting aluminum conductors to

Assortment of Typical Cable Connectors


FOR NON-METALLIC SHEATHED CABLE
Snap-in types
Box types
FOR SE CABLE
Watertight types
Also designed for SE cable when used indoors
FOR ARMORED CABLES
Straight box connector types
Angle-type
45°
90°
Duplex types

REPRESENTATIVE TYPES of cable connectors are shown in drawing for use with non-metallic sheathed cable, SE cable and armored cable installations. Such fittings are classified as straight connectors (snap-in or box types), angle connectors (45° or 90°), or duplex types.

Current news reports

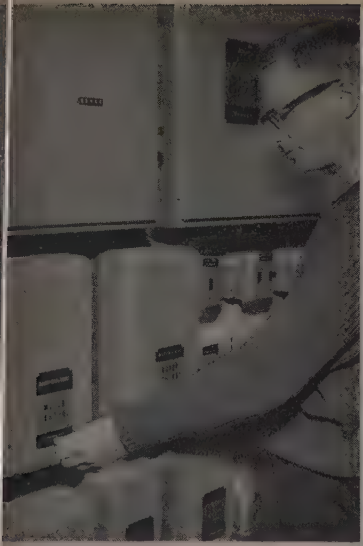
WHAT'S HAPPENING IN ELECTRICAL SERVICES?

Highlights: A new 100-, 50- and 25-kvar capacitor line. A load-break switch that provides complete system and personnel safety. These examples demonstrate the extra value that is standard with Allis-Chalmers...the greater efficiency and added productivity that are yours when you buy A-C products, systems and services. Call your nearby Allis-Chalmers office for details or write Allis-Chalmers, Milwaukee 1, Wisconsin. A-1590

Metal-clad safety for your personnel... A roll-out load-break switch that completely isolates the switch from live current. Fuse changing and switch maintenance handled with maximum safety. The roll-out element cannot be withdrawn or returned to the cubicle with the switch in the closed position.

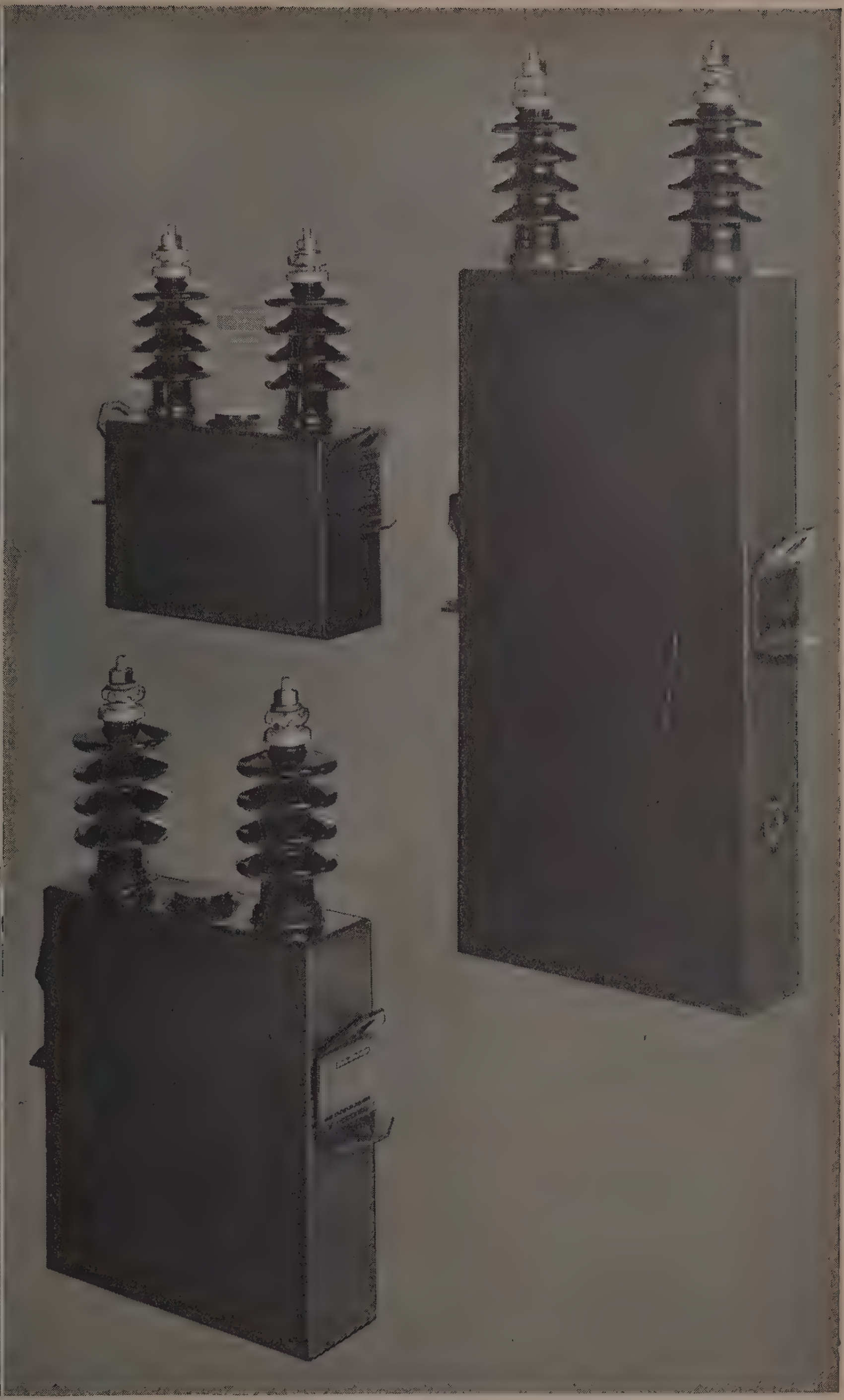
Load center substations cut costs! Ventilated dry-type transformers require less maintenance. You keep line losses at a minimum by locating substations close to your load centers. Other A-C advantages: a low-voltage breaker compartment that's completely isolated from bus compartment and other breakers; manual or electrical stored-energy closing; LCS units that are preplanned for expansion. Specify A-C substations with dry-type, oil-filled or *Chlorextol*-filled transformers.

Chlorextol, Super-Seal, Poxeal and Vari-Tex are Allis-Chalmers trademarks.



Dependable motor starters: Two years ago, A-C engineers traded the bulk in low-voltage motor controls for the savings of simplicity. With this came exceptional reliability, demonstrated by a substantial drop in the replacement parts business. You can be sure of fewer shutdowns when you specify A-C motor control—still the most advanced, easiest to maintain!

***Vari-Tex* speed changer takes corrosive atmosphere in stride:** At a chemical company, this 25-hp *Vari-Tex* speed changer drives a pump through a single reduction gear unit. It operates in an atmosphere of hygroscopic potash dust which is highly corrosive when wet. *Poxeal* insulation system equips the open *Super-Seal* motor to deliver a long, trouble-free life.



New, lighter, smaller . . . A-C adds 100-kvar size to extended-foil capacitor line. New Allis-Chalmers 100-kvar 95-kv-BIL capacitor weighs just 98 lb, has an all-aluminum case! To complement the new 100-kvar line, the 25- and 50-kvar units have been redesigned with aluminum cases, weights reduced to 37 and 58 lb respectively for 95-kv-BIL units. Mounting centers are still 15⅝ in. and case widths are 4 in. for all sizes from 2400 through 7960 volts.

ALLIS-CHALMERS

copper conductors will have a spacer so that the two different metals will not touch each other. The UL does not list any connector where aluminum and copper conductors will not be so separated.

For electrical connections in circuits rated above 600 volts, proper insulation is as important as providing the actual continuity of the current path. Splices and terminals must be made carefully in full conformity with instructions of connector manufacturers.

Several manufacturers feature splicing kits for making high-voltage splices. These kits will vary according to the circuit voltage and type of cable (interlocked armor, neoprene-jacketed with or without shielding, or lead-covered) for the particular conductor insulations.

A common high-voltage connecting device is the pothead, which is used to connect cables to equipment or to other circuits. A pothead is a sealed terminal which provides connection to the conductor in the cable, provides moisture-proofing for the conductor's insulation and seals in cable impregnating oil.

Cable Connectors

Cable connectors are designed to connect metallic or non-metallic cables to enclosures. Such connectors are designed for certain sizes of cable (12/2, 10/3, 8/3 etc.) and are available as straight or angle (45° or 90°) types. Single straight connectors accommodate one cable, and the duplex straight connector will handle two cables with No. 14 or No. 12 conductors.

For metallic cables, the function of the connector is to insure a continuous metallic bond through the armor to the metal enclosure to which the cable is connected. Connectors for armored cable, (Types AC, ACT, ACL, and AVL) are generally the solid-body single setscrew type; single-screw hinged type; two-screw type; or single- or two-screw, straight squeeze type.

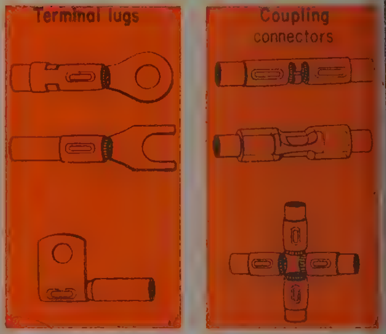
For mineral-insulated cable (Type MI), special connectors are used and are designated as Type "O" for general applications and as Type "H" for use in Class I, (Groups C and D) and Class II hazardous locations.

Connectors for SE cable are available in watertight or non-watertight types with the latter used indoors only.

Various types of connectors can be obtained for non-metallic sheathed cables. Since the purpose of connectors for such cables is merely to provide a reasonable clamping action, the connectors must secure the cables without injuring them. For the smaller cable sizes, low-cost snap-in or wedge-type connectors can be obtained, and these fittings do not require threaded throats and locknuts. Several types of snap-in type connectors can be installed in a ½-in. knockout either from the outside or inside of an enclosure.

Accompanying drawings show representative types of cable connectors.

Compression Connectors
(Crimp or Indenter Types)



COMPRESSION CONNECTORS are of the indenter or crimp types, and are applied to conductors by hand, pneumatic or hydraulic tools. A variety of such fittings are available and they are widely used for connecting aluminum conductors.

MAGNETIC CONTACTORS

A magnetic contactor is an ON-OFF switch in which the opening and closing operations are effected by energizing an electromagnetic mechanism. Magnetic contactors are used to provide automatic and/or remote switching of feeders, branch circuits and individual loads. In their load-switching function, they perform actions identical to a manually actuated switch—a typical safety switch. In fact, if the switch control provided by any magnetic contactor did not have to be automatic or remotely operable, it could be replaced by a safety switch.

From the foregoing, it is clear that selection of a magnetic contactor for load switching follows the same considerations made in the selection of a safety switch. But selection of a magnetic contactor involves the additional considerations of type of electromagnetic mechanism and required characteristics of the control circuit. Efficient selection of magnetic contactors—i.e., for any particular application, selection of the unit which provides maximum effectiveness with maximum economy—depends upon a clear understanding of construction, operation and application of the variety of contactor devices available for use.

The following discussion covers equipment which is only magnetically operated and is used for the prime purpose of achieving automatic and/or remote operation. (Some contactors have a small manual operator for emergency or convenience). It does not cover heavy-duty service-entrance switches or power circuit breakers which have electromagnetic action for convenience or necessity in operating their large, high-inertia contact mechanisms or have magnetic operation in addition to manual operation. Such magnetically operated devices are covered in the section on "Switches."

The basic magnetic contactor is magnetically operated by energizing the operating coil to close the

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DIVISION VAN HUFFEL TUBE CORPORATION • WARREN, OHIO

Selecting A Magnetic Contactor

1. Based on the type of load to be controlled, the stability of the system voltage, considerations of hum noise when magnetically held contactors are used, frequency of switching operations, desirability of low-voltage protection or low-voltage release, the first step in selecting a contactor is to decide upon either the magnetically held or mechanically held type.
2. The operating voltage of the circuit to be controlled will determine the required voltage rating of the contactor. And the number of lines to be switched will determine the number of poles in the contactor.
3. The nature of the load—either non-inductive, such as incandescent, fluorescent or other type of lighting, or other resistive loads, or inductive, such as motor loads—will narrow the selection down to those contactors which have the necessary load-closing and load-interrupting current ratings. For tungsten-lamp loads the contactor must be able to handle the high inrush currents on closing; and for inductive loads, the device must be able to safely and effectively break the load. For mixed loads of lighting and motors, the contactor must be rated capable of breaking the locked-rotor motor load in amperes plus the amperes of lighting load.
4. The total current or horsepower rating of the load to be controlled indicates the required size of contactor.
5. Selection of the control voltage for the operating coil of the contactor must be made next. Standard control voltages are: 24, 120, 208, 240, 277, 480 and 550 volts, and coils can be provided for any voltage regardless of the voltage of the switched circuit. If the control circuit voltage is the same as the phase-to-phase or phase-to-neutral voltage of the circuit being controlled by the contactor, the control circuit can be simply tapped from the line-side terminals of the contactor. If the voltage is different from the controlled circuit voltage, a control transformer will have to be added to the contactor to obtain the control voltage, with the transformer fed from the line side of the contactor. Or the control voltage, whatever its value is, might be derived from a separate ac or dc source and not from the controlled circuit.

   Safety considerations frequently dictate the use of lower control circuit voltages when the voltage of the controlled circuit is 440 or higher. But control circuits can be run safely at voltages up to 550 volts, and it should be remembered that the higher control voltages minimize voltage drop problems in the control circuit conductors to outlying pushbuttons or other pilot devices, often permitting necessarily long control circuits and smaller sizes of control wires.
6. The proper enclosure must be selected for the contactor—an individual enclosure of suitable construction for the conditions at the place of installation, or a mounting space in a panel or switchboard.

contacts and is magnetically held in position by maintaining current flow through the coil. The coil supply circuit is generally tapped from the line side of the magnetic switch itself.

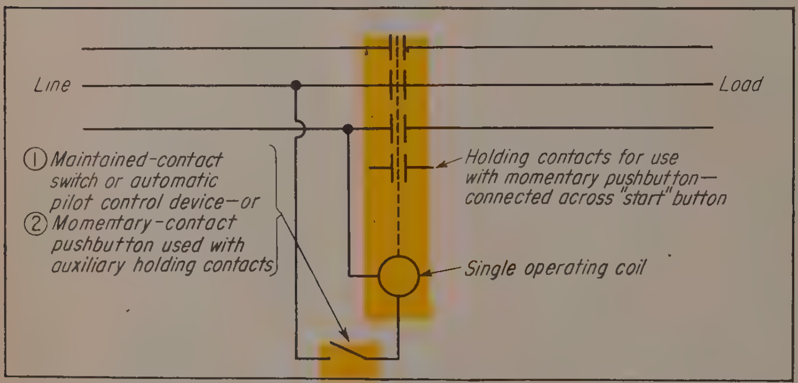
Magnetically held contactors are available for remote and automatic switching of ac and dc load circuits. Standard units are made and rated for high inrush current conditions of switching tungsten filament lamps. They are also rated for heating loads and fluorescent lighting loads, and, to the limit of their ability to break locked-rotor current, can be used to control motor loads when running overload protection is provided elsewhere. Typical contactors of this type are made in a wide range of ratings up to about 1000 amps, one to four poles, to 600 volts.

A variation on the basic magnetic contactor is the mechanically held contactor, in which the operating coil is momentarily energized to close the contacts and momentarily energized to open the contacts, as shown for two different types of mechanically held contactors in an accompanying illustration. During the time that the contacts are closed or open, the coil is not energized, and the contactor is held closed by some mechanical means or by a permanent magnet arrangement. Because of the definite switch action—with mechanically maintained open and closed positions—such a magnetic contactor is commonly distinguished from the magnetically held type by calling it a "remote switch"; i.e., a mechanical switch which can be operated in remote places by means of a long control arm (the control circuit to the switch is the arm and the operating coil, in effect, is the hand).

As the name implies, a remote switch offers operation of the contact assembly from one or more distant control stations. In such applications the switch is placed in the circuit which it is to switch. This may be in the middle of a split-bus panelboard where the switch controls one section of bus. It may be adjacent to a panel, where the switch controls a branch circuit or feeder from the panel. Or it may be placed upon a column, where it switches lighting circuits for, say, an industrial area. Then in each case, control conductors are run in cable or conduit from the switch enclosure to one or more control points at which pilot devices provide for operation of the remote switch. The pilot devices may be momentary pushbuttons, toggle switches or an automatic device like a time switch.

The mechanically held contactor will not change its operating position—will not trip out—on voltage dips or failures, as magnetically held contactors will do. For this reason, it offers distinct advantage on circuits to lighting and other loads where conditions of voltage fluctuation, which do not hurt the load devices, would keep dropping out magnetically held contactors. Mechanically held contactors can

Magnetically Held Contactor


Line
Load
① Maintained-contact switch or automatic pilot control device—or
② Momentary-contact pushbutton used with auxiliary holding contacts
Holding contacts for use with momentary pushbutton—connected across "start" button
Single operating coil

This type of contactor is essentially a magnetic motor starter without the running overload relays. The coil must be continually energized to hold the contacts closed. De-energizing the coil opens the contactor. Because it depends upon coil voltage to keep the contacts closed, this type of contactor can drop out if connected on a circuit where voltage fluctuations dip below the holding value of voltage for the coil. But this characteristic provides low-voltage release or low-voltage protection, depending upon the control circuit, for motors.

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eneral Electric *Bonus Line** Ballasts on't leak or smoke at end of life

neral Electric Bonus Line Ballasts are designed to protect inst smoking, leaking, or any of the unpleasant conditions which netimes occur when a ballast fails.

An integrated thermal protection system de-energizes the ballast rmanently when extreme temperatures—sometimes characteristic ballast end of life—are detected. Voltage or current surges will affect the system. The ballast is de-energized only when failure *lready in progress.*

The protective system consists of two non-resetting thermal pro-tors, one located near the coils, the other inside the capacitor. need for external, individual ballast fusing.

Specify General Electric's Bonus Line Ballasts. They give many ars of reliable service before end of life. Then they bow out grace-ly.

For a technical paper on ballast thermal protection, contact your neral Electric Ballast Sales Engineer. Or write to Section 403-04, neral Electric Company, Danville, Illinois.

rademark, General Electric Company.

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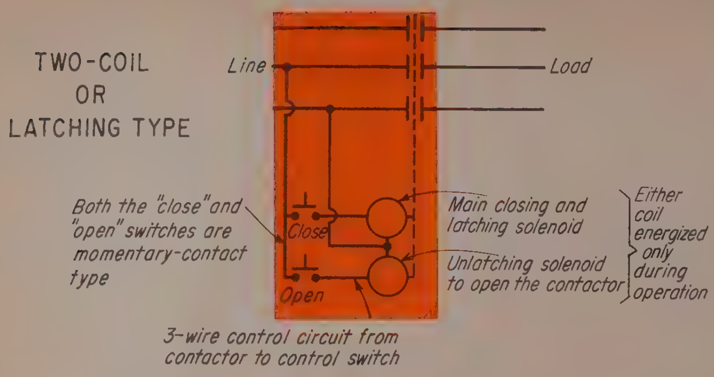
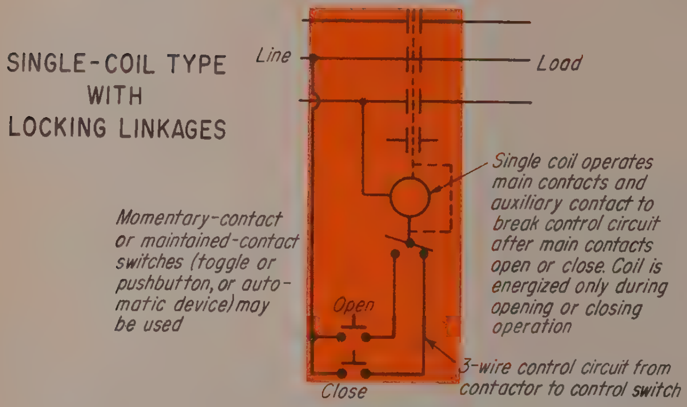
NEW...Another Added Value From *Bonus Line** Ballasts!

Certain fluorescent fixtures equipped with General Electric Bonus Line Ballasts have recently been listed by Underwriters' Laboratory, Inc., as complying with National Electrical Code requirements for direct surface-mounting on combustible, low-density, cellulose fiberboard ceilings. Contact your G-E Ballast Sales Engineer for details.

Mechanically Held Contactor


TWO-COIL
OR
LATCHING TYPE
Line
Load
Both the "close" and "open" switches are momentary-contact type
Close
Open
Main closing and latching solenoid
Unlatching solenoid to open the contactor
Either coil energized only during operation
3-wire control circuit from contactor to control switch


SINGLE-COIL TYPE
WITH
LOCKING LINKAGES
Line
Load
Single coil operates main contacts and auxiliary contact to break control circuit after main contacts open or close. Coil is energized only during opening or closing operation
Momentary-contact or maintained-contact switches (toggle or pushbutton, or automatic device) may be used
Open
Close
3-wire control circuit from contactor to control switch

This type of contactor has a magnetic operating mechanism to close the contactor by energizing a coil and to open the contactor by energizing the coil. Various coil hookups are used. In the latching-type contactor, one coil closes the contacts which are held in place by a latch. A second coil is used to unlatch the contacts from the closed position. In another type, one coil moves the contacts closed and a second coil moves them apart, with interlocking of the two coils and a mechanical "hold" for the contacts in either position. Still another type uses only one coil to open and close the contacts.

In the mechanically held contactor, the contact assembly is held in the closed position after the closing coil is de-energized. To open the contactor, the opening coil is momentarily energized to overcome the holding force and move the contacts to the open position. Only momentary coil energizing is required for either opening or closing. During the time that the contacts are closed or open, the coil is not energized; and the only time that electrical energy is consumed is during opening or closing movement of the contacts.

Typical Data for Operating Coils

NEMA CONTROLLER SIZE	COIL WATTS	COIL VOLTS 60-cycle AC	COIL CURRENT INRUSH (Open Magnet) Amperes	COIL CURRENT INRUSH (Open Magnet) Volt Amperes	COIL CURRENT NORMAL (Sealed Magnet) Amperes	COIL CURRENT NORMAL (Sealed Magnet) Volt Amperes
0 & 1	6.0	24	8.00	187	1.02	24.2
		110	1.70		0.22	
		220	0.85		0.11	
		440	0.42		0.055	
		550	0.34		0.044	
2	18.4	110	4.4	484	.55	61.0
		220	2.2		.28	
		440	1.1		.14	
		550	0.88		.112	
3 & 4	22.0	110	8.7	957	.68	75.0
		220	4.35		.34	
		440	2.17		.17	
		550	1.74		.14	

The data given here is typical catalog information on the actual coil currents for one manufacturer's contactors. Selection of a contactor always requires determination of the most effective coil circuit voltage. Reference to a table of this type facilitates evaluation of the operating coil in terms of the needs of the control circuit.

Contactor Current Ratings Up To 600 Volts

Size of Contactor	NEMA Ampere Ratings of Low-voltage (600v) AC and DC Contactors: 8-hour Open Ratings, Amperes — AC Contactors	NEMA Ampere Ratings of Low-voltage (600v) AC and DC Contactors: 8-hour Open Ratings, Amperes — DC Contactors	For AC Contactors Only, at Not Over 250 Volts: Tungsten-lamp-load Rating, Amperes
00	10 (9)	..	5
0	20 (18)	..	10
1	30 (27)	25	15
2	50 (45)	50	30
3	100 (90)	100	60
4	150 (135)	150	120
5	300 (270)	300	240
6	600 (540)	600	480
7	900 (810)	900	
8	1350 (1215)	1350	
9	2500 (2250)	2500	

NOTE: The ampere ratings of enclosed low-voltage alternating-current contactors shall be 90% of the 8-hour open ratings, as given in parentheses above.

The 8-hour ampere ratings are used in selecting a contactor for resistance heating, fluorescent lighting.

For use with motor loads, contactors must be selected in accordance with hp ratings given in manufacturer's literature.

The reduced current ratings given above for tungsten loads are required by the very high (10-20 times) inrush current on connecting to cold tungsten filaments.

Some manufacturers adhere closely to these values in rating their contactors. Other manufacturers have established specific values of current closing and current interrupting for their own particular contactors. Catalog data must be studied carefully to assume best application. Some catalog current ratings apply to either open or enclosed use, for tungsten and other non-inductive loads. No deratings are necessary.

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Time it. You'll find that it takes about 40 seconds on the average to pull a rule out of your pocket, unfold the rule, lay it on a piece of tube, mark the tube, refold the rule, and put it back in your pocket. The same measurement takes only *three seconds* when the tube is Republic ELECTRUNITE E.M.T.

The difference? ELECTRUNITE is marked from end to end in feet and inches—with "INCH-MARKS." These marks eliminate the problem of a flat rule on a round tube. They help you make accurate stubs and even back to back bends without time-consuming trial and error fittings. You are assured lower installed cost on every job.

ELECTRUNITE E.M.T. also has a "GUIDE-LINE" that runs the full length of the tube. Used with the Republic Bender, this line helps you keep bends in the same plane, save time and materials by avoiding "wows."

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SELECTION: Magnetically Held vs Mechanically Held

MAGNETICALLY HELD CONTACTORS provide effective remote switching control of power and lighting loads where stable circuit voltage will prevent objectionable low-voltage drop-out and where the inherent ac hum of continually energized coils will not be objectionable. They are particularly applicable to controlling motor loads where running overload protection is not required or is provided elsewhere. In such use, the magnetically held contactor can be arranged for low-voltage protection or low-voltage release for the motor load.

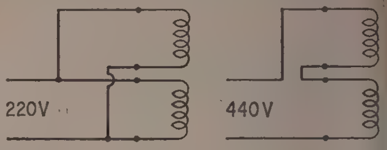
MECHANICALLY HELD CONTACTORS are best suited to use as remotely controlled safety switches. They are used for switching feeders, branch circuits and individual loads—lighting, motor or other power loads. They offer particular advantage where frequent ON-OFF switching is desired from a remote location, or where a single contactor is to be controlled from a number of different remote locations. This type of contactor responds only to energy input to the coil, either closing or opening, and maintains the contacts in either the opened or closed position regardless of the voltage condition of the controlled circuit. This is highly desirable on many circuits used for automatic processing where continuity of circuit connection must be maintained during voltage dips and power outages. Such continuity of connection is also important where the contactor is controlling lighting on a system where severe voltage fluctuations would drop out a magnetically held contactor.

A second important advantage of the mechanically held contactor is the absence of ac magnetostriction hum of the operating coil. Because the coil is only momentarily energized for opening or closing, the coil is not constantly carrying current while the contacts are in the closed position—as in the case of the magnetically held type. This suits the mechanically held contactor uniquely to application in quiet areas—schools, hospitals, office buildings, libraries—where very low ambient noise level would make even the slightest magnetic hum objectionable.

Typical Features of Contactors

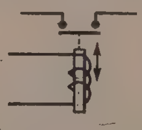
PLASTIC MOLDED OR ENCAPSULATED operating coils for higher resistance to mechanical injury and dampness, with better heat transfer for cooler operation and longer life.

DUAL-VOLTAGE COILS for use at either of the two voltages, e.g., 110 or 220 volts, 220 or 440 volts, provide flexible application and reduce maintenance stocks.

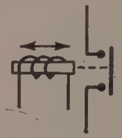


EASY CHANGING OF COILS AND CONTACTS in the field.

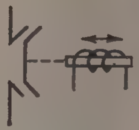
DOUBLE-BREAK CONTACTS for reduced arc erosion of contacts, providing better wear and longer life.



VERTICAL-LIFT solenoid has minimum friction

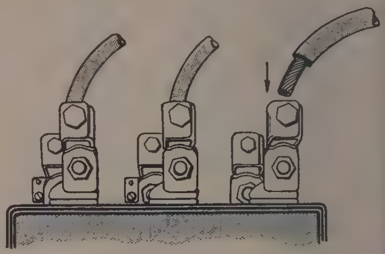


VERTICAL CONTACT position shakes dust off contacts



SLANTED-VERTICAL contacts provide wiping action

PRESSURE TERMINALS FOR CONNECTION OF WIRES to contactor, to reduce wiring time by eliminating wire loops at terminals. Connection is made by simple insertion of wire ends under screw pressure.



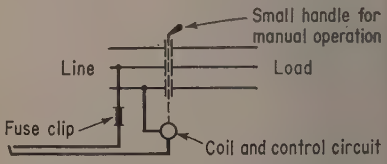
ASSEMBLY MOUNTS IN ANY POSITION for any layouts in panelboards.

STRAIGHT-THROUGH WIRING, with line terminals on top and load terminals at bottom, to avoid training wires in gutter.

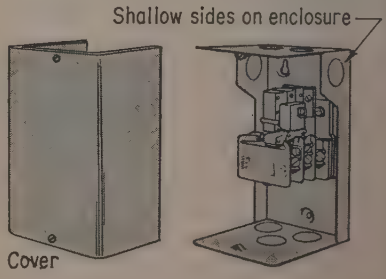
VARIETY OF ENCLOSURES—general-use, watertight, hazardous locations, etc.

MANUAL OPERATOR on contactor for local or emergency operation of contacts.

FUSE CLIP ON CONTACTOR for ready provision of overcurrent protection for control circuit.



WRAP-AROUND COVER ON ENCLOSURE to provide maximum working room in wiring of the contactor terminals.



be used for handling power and lighting circuits or circuits of combination power and light loads, offering remote switching from one or more control stations. Of course, ratings must be checked for inductive and non-inductive loads. Standard contactors of this type are available for remote control of feeder connecting and disconnecting. Typical mechanically held contactors are made up to 1000 amps.

To facilitate thorough control circuit design, operating coil currents for closing and holding different sizes of contactors and the wattage ratings of various coils are given for selection of proper pilot device ratings, as shown in an accompanying illustration. The operating coil circuit may be energized at the line voltage of the switched supply or through a control transformer.

Selection of the proper control transformer for a controller is a simple matter of matching the characteristics of the control circuit to the specs of the transformer. The line voltage of the supply to the motor determines the required primary rating of the transformer. The transformer secondary must be rated to provide the desired control circuit voltage to match the voltage of the controller operating coil. The continuous secondary-current rating of the transformer must be sufficient for the magnetizing current of the operating coil and must also be able to handle the inrush current. Of course, if any other devices are to be energized from the transformer, additional capacity must be provided.

POWER SOURCES

Storage batteries are recom-ended for three basic types of ap-ications: (1) to supply power here direct connection to normal tility service is impractical such s on industrial trucks or portable ghting; (2) as an emergency ower source when normal power is nterrupted; (3) to provide special oltage and current characteristics r laboratory work, meter calibra-on and similar applications.

Types of storage batteries avail-ble include: lead-acid, nickel-iron-lkaline, and nickel-cadmium. All perate on the same general prin-iple, but differ in characteristics. owever, because battery charac-eristics may vary widely depend-ng on specific construction fea-ures, application, and other fac-ors, it is recommended that final election be based on specific bat-ery models.

For example, lead-acid batteries re popularly used for industrial rucks and as an emergency power ource because they are moderately riced, have high efficiency (85% o 90%), are small and have short echarging cycles.

Nickel-iron-alkaline batteries are sed in the same applications when other characteristics are desired. As an example, they are rugged, have a long life and may be stored for long periods.

Nickel-cadmium batteries are particularly useful for application in temperature extremes. They are reputed to have been successfully operated at temperatures from −40 to +163 F. In addition, they have long life and low internal resistance

Important factors to consider when selecting a battery include: physical use (portable or stationary); type of container (rubber, glass, plastic); number of cells to obtain desired voltage (for nickel-cadmium and nickel-iron-alkaline cells, voltage is about 1.3 volts per cell; for lead-acid, voltage is about 2.1 volts/cell); amp-hr capacity.

Where space is limited, a silver-zinc or silver-cadmium battery can be selected. This type has a much higher output per unit than other batteries of equal size.

Rectifiers are widely used to change ac to dc in many industrial applications such as: battery charging; electroplating; arc welding; powering machine tools, crane and hoist motors; and synchronous motor excitation.

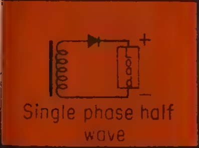
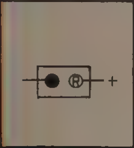
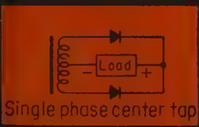
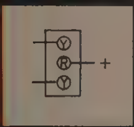
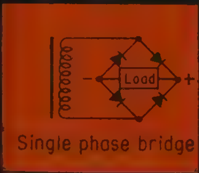
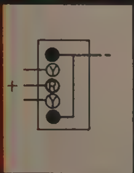
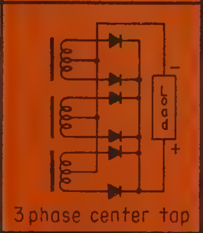
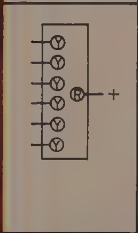
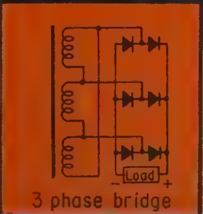
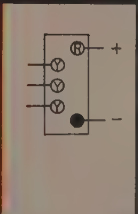
LEAD-ACID STORAGE BATTERIES supply auxiliary 125-volt control power for circuit breakers installed in process plant. Provided with glass containers, this type of battery is often selected for other stationary power-supply applications such as for telephone and railway signaling, alarm and emergency lighting purposes.

In general, rectifiers enjoy extensive use because they are flexible, easy to install, are efficient, and maintenance is simple.

Important selection considerations include: voltage rating, current rating, forward voltage drop, regeneration protection, maximum ac input voltage, life expectancy, dimensions, and cooling requirements.

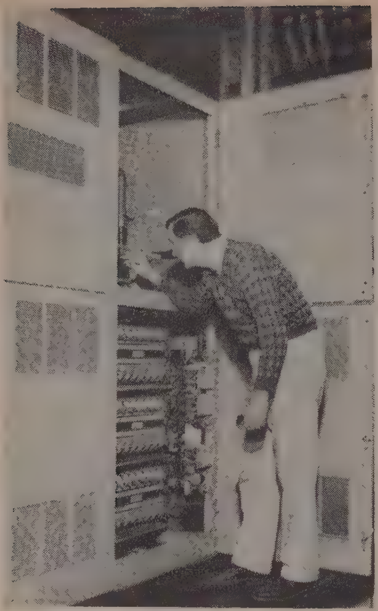
Because operating principles and applications of rectifiers vary extensively, careful consideration should be given to characteristics of each type.

Mechanical rectifiers operate on a principle similar to that of commutation on a direct-current gen-

RECTIFIER CIRCUIT	SINGLE-STACK CONNECTIONS	REMARKS
 Single phase half wave		Suitable for low-power applications. Circuit has poor efficiency (25-30%) and high dc ripple (about 121%).
 Single phase center tap		Suitable for low-voltage, high-current applications. Efficiency is 65-75%; dc ripple is about 48%.
 Single phase bridge		Suitable for low-voltage, high-current applications. Does not require center-tap transformer. Efficiency and ripple similar to single-phase, center-tap circuit.
 3 phase center tap		Suitable for low-voltage, heavy-current applications. Provides high efficiency (85 to 90%); low ripple (about 4.2%). Requires center tap at each secondary phase winding.
 3 phase bridge		Suitable for high-voltage (220 or 440 volts dc output). Does not require center-tap transformer. Efficiency and ripple is similar to three-phase, center-tap circuit.

Color code: R – Red – Positive; ● – Black – Negative; Y – Yellow – A.C.

ELENIUM RECTIFIER connections are shown for single-stack units. Additional stacks may be connected in various ways to btain higher voltage and current ratings. Large, multi-stack assemblies can provide up to 1000 amps at 125 volts



SILICON RECTIFIER is installed in parallel with three mercury-arc rectifiers to supply dc power for a large steel mill. Silicon rectifier is rated 1000 kw, 4000 amps at 250 volts. The three mercury-arc units are 1000-kw each. Silicon cells are mounted on busbars in lower section of panel. Top panel section houses cooling equipment.

erator. That is, negative alternations of the ac sine wave are inverted by cam-controlled contacts producing a pulsating current. A commutating reactor modifies the ac wave so that the contacts can make or break without heavy arcing providing for long life contacts.

The principal advantage of mechanical rectifiers is that of very high efficiency (94% to 97%) over a broad range of loading and voltage. Units are available with current ratings up to 10,000 amps at voltages between 50 and 600 volts.

Selenium and copper-oxide rectifier operation is based on the principal that a layer of selenium (or cuprous oxide), when placed on a disk of copper, will allow current to flow in one direction only. Individual disks or cells are connected in various ways to form stacks that provide a wide range of possible voltage and current ratings.

Because selenium and copper-oxide rectifiers are comparatively light in weight, have no moving parts and need no special foundation, their installation costs are moderate. In addition, they are rugged, reliable, have long life and require practically no maintenance.

Selenium rectifiers are available in a large number of ratings to cover most applications. A new, small-sized high-density selenium rectifier, designed for low-voltage (26-32 volts) high-current applications, can carry about 380 amps at 40°C, and up to 948 amps in forced-cooled applications. Large floor-mounted units range up to 125 kw, delivering 1000 amps at 125 volts. Efficiencies of these rectifiers are about 80% for single-phase units; 92% for 3-phase units.

Silicon rectifiers consist of small semiconductor wafers, about the size of a quarter, that allow current flow in one direction only. A single cell may carry as much as 250 amps; or many cells may be installed in "package" units to handle very high currents.

Silicon rectifiers have the inherent advantages of high reliability, negligible reverse losses even at high temperatures, and very high efficiency. Other advantages include comparatively low installation cost, small size and minimum maintenance.

Particularly suited to applications in the electrochemical industry, a packaged silicon rectifier can deliver 60,000 amps at 150 volts for a copper production installation. Designed to provide dc power for vacuum arc furnaces, submerged arc welding, and anodizing and plating, a new compact unit can deliver up to 3000 amps at 40 volts. Silicon rectifier stacks are available for use at voltages up to 1500 volt

When many cells are connected parallel to deliver high current special transformer taps or balan ing reactors are incorporated to a sure proper current division. addition, high-current rectifi units require cooling, which is pr vided for by forcing air over coo ing fins mounted on the silicon cell or by incorporating water-coole bus sections with the cells mounte directly on the bus.

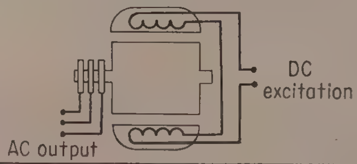
Germanium rectifiers find man applications in the electrochemic industries. Characteristics and a vantages are similar to silicon re tifiers; however, germanium uni are more suitable for low-voltag operation and have lower temper ture ratings.

Germanium rectifiers are avail ble with various current ratings voltages up to about 200 volts. F a plating process, a typical unit rated, 10,000 amps at 12 volts.

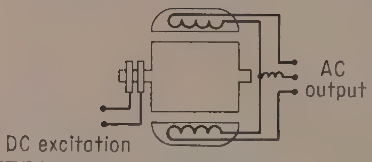
Mercury arc rectifiers operate the principle that a mercury ar when operating in a high vacuu will pass current in one directi only. The glass tube type, used applications up to about 50 kw, ma incorporate dual anodes to perm full-wave rectification.

The ignitron is a more rugge metallic-envelope type and is cap ble of handling high currents high voltages. Various types ignitrons are available. Some ma

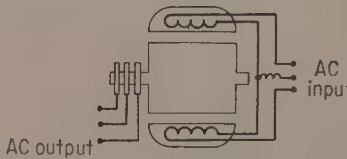
Basic Types of Alternating Current Generators



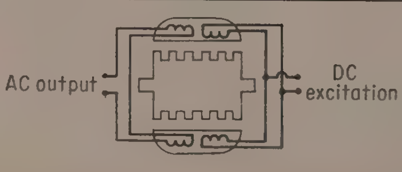
REVOLVING-ARMATURE alternator has dc excitati connected to stator. AC voltage is taken from armatu through slip rings and brushes. This method is used machines up to 25 kva at frequencies up to 120 cycle



REVOLVING-FIELD alternator is most commonly us for 60 cycle generation; can be used for frequencies u to about 1000 cycles. This type can be constructed f high kva capacity.

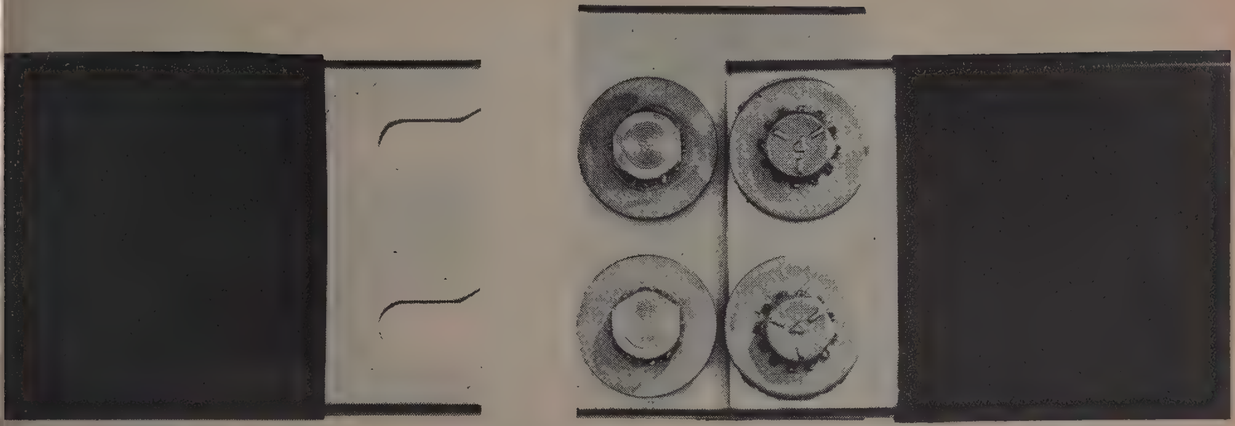


INDUCTION FREQUENCY CHANGER is essentiall a wound-rotor motor driven in opposite rotation. Chang ing the speed of rotation will provide various voltage and frequencies. These units can be used for applica tions up to about 500 cycles.

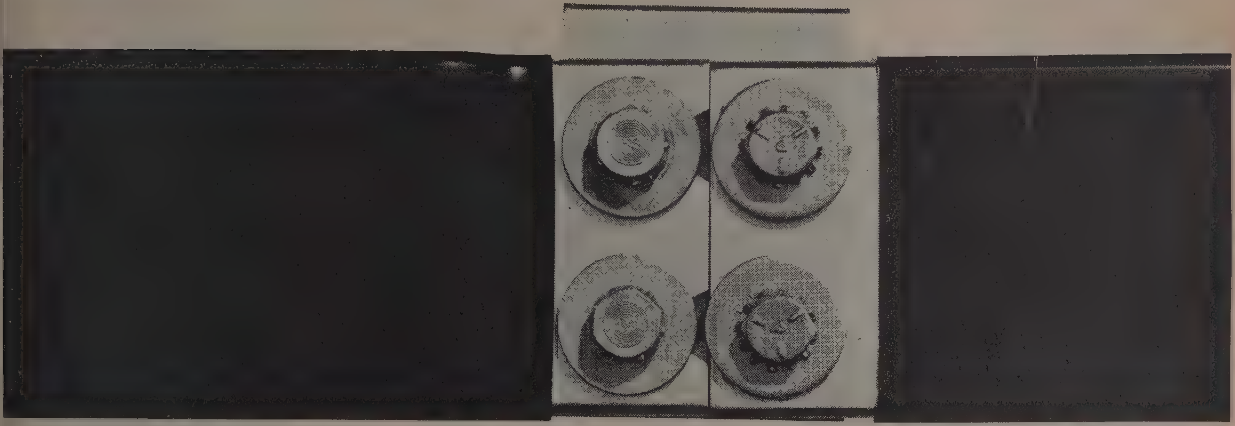


HIGH-FREQUENCY INDUCTOR ALTERNATOR used for generation of frequencies ranging from 400 t 10,000 cycles. The revolving element is a notched cor without windings. This type is available in ratings u to 500 kw.

just slip in place



and tighten bolts



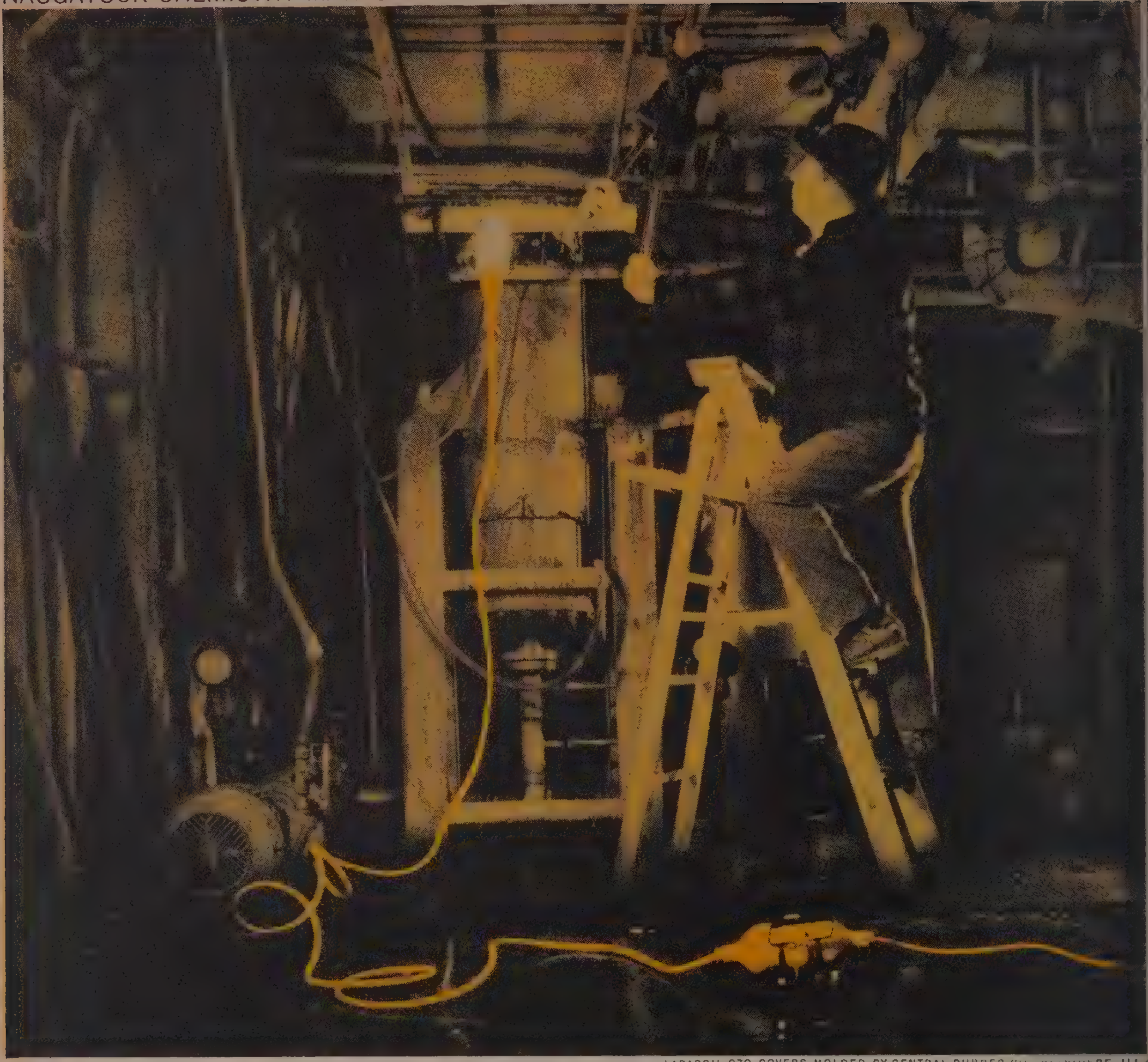
Westinghouse Plug-In Low Impedance Bus Duct cuts installation costs

Exclusive Westinghouse factory-installed captive hardware eliminates the time-consuming alignment of joints; threading and fastening of loose hardware. Just slip together and tighten from either side for a high strength, low power loss connection. Its lighter weight and small size (up to 33% smaller than other makes) contribute to easier handling especially on limited-space jobs. In one actual installation, studied by S. M. Dix and Associates of Grand Rapids, Michigan, two men installed a complete section of Westinghouse duct in less than eight minutes! Installed cost is the important cost, and no other plug-in low impedance bus duct can be installed faster than Westinghouse.

In ratings of 600 to 4000 amperes, this duct is available with copper or aluminum conductors and a complete line of fittings, hangers, and plug-in units. For further information contact your Westinghouse representative; or write, Westinghouse Electric Corporation, Standard Control Division, Beaver, Pa. *You can be sure . . . if it's Westinghouse.* J-30340

Westinghouse

NAUGATUCK CHEMISTRY MAKES THINGS HAPPEN



PARACRIL OZO COVERS MOLDED BY CENTRAL RUBBER CO., BELVIDERE, ILL.

Safety, safety, safety!

PARACRIL-OZO Here's safety in a droplight such as you've never seen before...safety in appearance, safety in material, safety in design.

This new and patented LoVOLT droplight and extension cord by Daniel Woodhead Company* has its own built-in transformer to reduce line voltage to a safe 6 volts at the outlet end, eliminating danger of serious shock even under hazardous working conditions.

Molded PARACRIL®-OZO covers form a watertight shield to protect the transformer and light socket units under the severest use conditions... gives the finest possible protection against cutting, gouging, abrasion, weather, and the attack of ozone, oils, fats, acids, and other chemicals.

And PARACRIL-OZO's exceptional color retention allows a bright yellow cover that won't fade or darken, keeps these units visible even in close-to-total darkness.

Next time you need a rubber that's outstanding for its combination of toughness, color retention, and resistance to weather, oils, and chemicals, take a look at PARACRIL-OZO. You'll soon see why so many manufacturers have begun to enjoy the unique selling advantage only PARACRIL-OZO offers.

*Chicago, Ill.

Naugatuck Chemical

Division of United States Rubber Company...Dept. 534 PA Elm Street, Naugatuck, Conn.

US RUBBER

DIST. OFFICES: Akron · Boston · Chicago · Gastonia · Los Angeles · Memphis · New York · Phila. · **CANADA:** Naugatuck Chemicals, Elmira, Ont. · **CABLE:** Rubexport, N.Y.

be of single-anode construction for use as a high-current contactor; others may be furnished with 6, 12 or 18 anodes for multiphase rectification.

Sealed-tube ignitrons, ranging in size from about 3- to 8-in. diameter, are commonly used for installations up to 500 kw at 250 volts, and 1000 kw at 600 volts. Typical applications include powering dc motors in industrial plants, power supplies for speed regulators, and electronic exciters for large turbine generators.

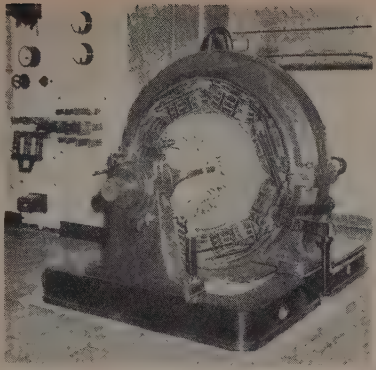
For high-power installations in industrial, transportation and electrochemical applications, a rugged, steel-tank, pumped ignitron rectifier may be selected. This type requires auxiliary vacuum-pumping equipment for satisfactory operation. Ratings may be extremely high. In an aluminum reduction installation, a pumped ignitron assembly supplies over 100,000 amps at 850 volts.

Recently, a pumpless ignitron rectifier was made available for high-power applications ranging from 750 kw, 250 volts to 5000 kw at 850 volts and above.

Practically all ignitron rectifiers require water-cooling systems, excitation control and anode protection equipment.

Main advantages gained by use of ignitron rectifiers include a high efficiency (90% to 95%) over entire range of loading, unattended operation, high overload capacity, noiseless and vibrationless operation, comparatively low weight, and negligible maintenance.

Thyratron rectifiers are gas-filled electronic tubes (glass or metal) which permit current flow from cathode to anode only. In contrast to other gas-filled rectifiers, they are furnished with a grid to control firing of the arc current flow. They feature highly efficient operation. Basically a low-power device, the thyratron rectifier is often selected for control applications such as regulators for alternator fields, lamp dimming and motor speed controllers.



ROTARY CONVERTER, rated 300 kw, supplies 250 volts dc for elevator motors, machine-tool drives and for excitation of synchronous motors. Alternating current enters converter through slip rings at one end of the armature; direct current is delivered through a commutator and brushes at the other.

DC GENERATOR, rated at 600 kw, 600 volts, supplies armature voltage to rolling-mill dc motors. Direct-current m-g sets provide the advantages of reliability and proven long life. Because synchronous motors can operate with a leading power factor, an 875-hp synchronous motor was selected to drive generator.

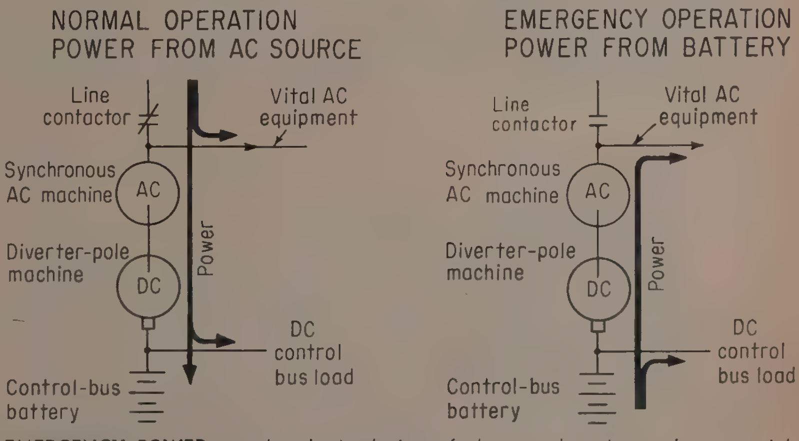
Generators, both ac and dc, are often the most advantageous and economical source of auxiliary power. Selection of a generator depends on various factors concerning its application but for most effective utilization the following pertinent factors should be considered: type of application; type of machine, dc shunt or compound, or ac synchronous alternator; type of driver, engine or motor; kilowatt, voltage, speed, phase, frequency and temperature ratings; voltage regulation; parallel operation; reliability and starting requirements; efficiency desired; cost and special features.

In addition, a number of mechanical features should be considered such as type of enclosure—drip-proof, splash-proof, etc.; number and type of bearings; coupling; brush rigging; type of insulation; frame size and mounting.

Direct-current generators may be generally classified according to the manner in which their field windings are connected, series, shunt, or compound. When the generator field is connected in series with the armature winding, it is called a series generator. This type is not often used except in conjunction with other generators or batteries.

A shunt generator has its field connected in parallel with the armature. This type is well suited for low-voltage electrolytic work with the shunt field separately excited.

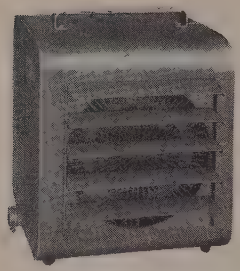
The compound generator has both a series field and a shunt field. This type provides good voltage regulation and is often selected for power and lighting and may be of 2-wire or 3-wire design. Two-wire generators are usually wound to provide 125 volts. For dual-voltage supply, 3-wire generators provide

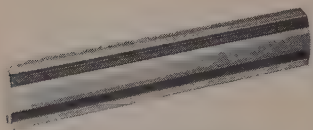


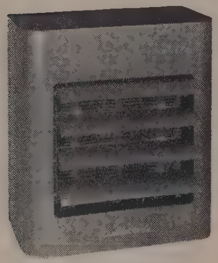
EMERGENCY POWER may be obtained via a fuel-powered engine or by a special motor-generator set as shown above. System shown provides continuous power for essential operations such as computer installations or telemetering and supervisory systems. Under normal conditions, the ac motor drives the dc generator which float-charges batteries and supplies the dc control bus. If the ac power fails, the batteries supply power to the dc bus and dc generator which now acts as a motor. The ac machine, after proper field excitation, performs as a generator to supply emergency ac power. Special relays and regulators are required for proper operation.

not just for many . . . or for most . . .

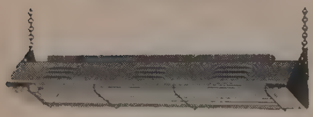
there is an Electromode


PORTABLE SUSPENSION HEATER


LOW LEVEL BASEBOARD HEATER


1410 SUSPENSION HEATER

PORTABLE HEATER


QUARTZONE HEATER

For example, a visitor in a typical Electromode electrically heated industrial plant might observe:

IN THE GUARD HOUSE . . .
THE ELECTROMODE PORTABLE-SUSPENSION HEATER. Compact, efficient, designed to keep employees comfortable in high heat-loss areas.

A WARM RECEPTION . . .
. . . is accorded every visitor when the reception office is uniformly warmed by an ELECTROMODE RECESSED WALL DOWN-FLO HEATER. "HE'LL SEE YOU NOW, SIR."

Notice the hall as you walk to his office. None of the usual chilly floor-level draft with an ELECTROMODE COMMERCIAL DOWN-FLO HEATER on the job.

INSIDE THE PRIVATE OFFICE . . .
. . . decisions are made in modern comfort. Efficient ELECTROMODE BASEBOARD HEATERS create the perfect climate for executive planning.

DOWN THE HALL . . .
. . . in the spacious General Office, temperature control means comfortable, productive employees. Nothing does the job as well as ELECTROMODE COMMERCIAL CONVECTOR HEATERS.

TO THE PLANT . . .
. . . where Electromode 1410 Suspension heaters provide comfortable, directed heat. Being suspended, they circulate heat evenly around floor-level obstructions, and free valuable floor space for more productive use.

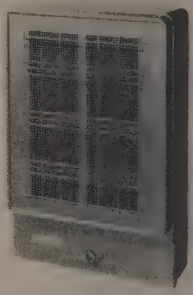
SPECIAL PROBLEM?
Working with volatile chemicals or gases? Perfectly controlled heat from an ELECTROMODE EXPLOSION-*PROOF* HEATER makes work safe in hazardous locations.

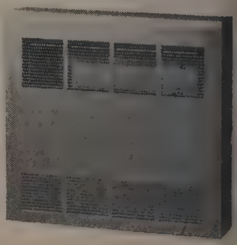
FOR MAINTENANCE CREWS . . .
. . . working all around the plant, an ELECTROMODE PORTABLE HEATER in any desired capacity, keeps them warm when exposed to cold area jobs.

ON SHIPPING DOCKS . . .
. . . where exposure is greatest, ELECTROMODE QUARTZONE HEATERS keep the crew happy and healthy without heating all outdoors. Projects infrared rays to warm people within the area regardless of air temperature.

This is only a representative sample of the complete line of ELECTROMODE heaters and heating sytems. Over 400 in all, units to meet every application for home, farm, commercial and industrial heating.

WALL MOUNTED DOWN-FLO HEATER


DOWN-FLO HEATER


COMMERCIAL CONVECTOR HEATER

EXPLOSION-PROOF HEATER

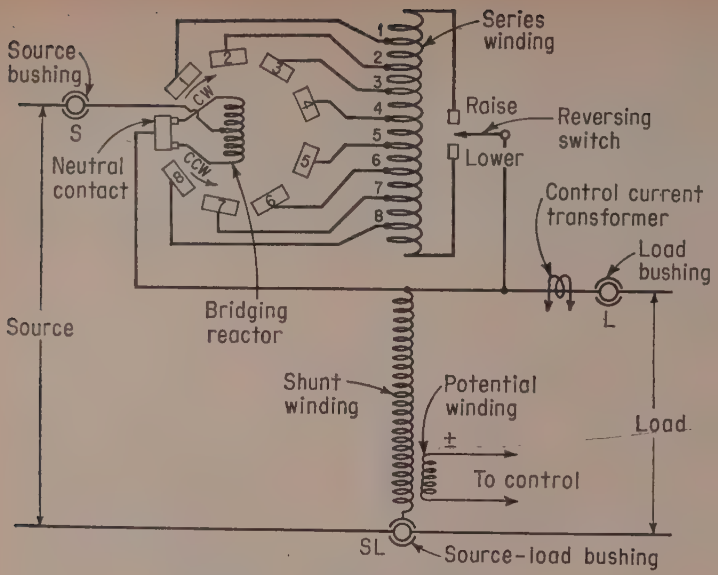
heater for *every* application!

Heating contractors and engineers must supply the answers to many unusual heating problems; but that's not difficult for those who have learned that ELECTROMODE *manufactures* the solution to every heating problem. Over thirty years of aggressive leadership and progressive achievement has kept ELECTROMODE setting the pace . . . not just keeping up with it. There is an ELECTROMODE HEATER designed to heat ANY area under ANY condition.

These men are ELECTROMODE engineers, experts whose experience extends into the most complex and technical areas of electric heating. Working in combination with the latest facilities for test and development, they represent a major force in the continued growth of the electric heating industry. The new Unit Heater Blower illustrated below is the most recent example of their progress. With adjustable louvers and automatic controls, it is compactly designed to distribute heat more uniformly and efficiently than any of its competitors. The fact is, for over thirty years Electromode men have *consistently* found the right answers FIRST. It makes sense to specify ELECTROMODE . . . the electric heating *specialists*.

UNIT HEATER BLOWER

®Electromode Dept. ECM-52
Division of Commercial Controls Corporation **ROCHESTER 3, N. Y.**



POWER CIRCUIT SCHEMATIC

STEP LOAD-RATIO voltage-regulator power diagram shows operating principles. The movable center contact has dual contact fingers and a bridging reactor which permit tap changes without interrupting current flow. As the center unit rotates to correct voltage variation, the dual fingers will be on the same stationary contact, or one of them will be on each of two adjacent stationary contacts. Thus the circuit is never broken. This arrangement provides 16 separate positions or 32 steps for voltage raise or lower.

125/250 volts and are usually flat- or over-compound wound to provide good voltage regulation.

A special generator, called a diverter-pole generator, has excellent voltage regulation and is particularly suited for battery charging.

The rotary convertor is a highly efficient rotating machine capable of delivering large amounts of direct-current power. It is actually a combination synchronous motor and dc generator on one shaft. Alternating current enters through slip rings at one end of the armature; direct current is delivered through a commutator and a set of brushes at the other. Rotary converters are selected for many dc applications such as electrolytic and electroplating processes, supply for dc motors, and aluminum production.

Motor-generator sets are often selected as a dc power source because they are rugged, reliable and have a proven long life. They are particularly advantageous when equipped with a synchronous motor to correct low power factor. Main disadvantages are that they require regular maintenance and that their efficiency drops off considerably at light loadings.

AC generators are used extensively for auxiliary power supply in case of normal service failure; and for generation of high-frequency power for lighting, process heating or other industrial applications.

When selecting a generator for any one of many possible applications, the generator selection factors mentioned earlier should be considered. Moreover, when the generator is to be used as an emergency power supply, careful consideration must be given to the type of driving power, which is usually a fuel-powered engine.

Engines may be gasoline, natural gas, bottled gas, steam or diesel ranging from low-rated hp sizes to several hundred hp. Control may be obtained manually, remotely or automatically. Auxiliary equipment includes starting batteries for larger units; control panels, relays and transfer switches for automatic transfer of power. Some units are stationary; others are portable.

Important engine selection considerations include: reliability, capacity matched to loading, starting ability, location, foundation, cooling requirements, and fuel storage.

To supply high-frequency power for high-cycle lighting, induction heating, high-speed motors and the like, high-frequency motor-generator sets and static frequency converters are utilized. When it is essential that output frequency be accurate, the m-g set drive motor should be the synchronous type because synchronous motors have stable speed regulation and output frequency depends on generator rotor speed. When an induction motor is used as a prime mover, the generator output frequency will vary 2% to 4%.

High-frequency m-g sets can be obtained to supply output frequencies ranging from 80 to 10,000 cycles. Power ratings range up to 500 kw at standard voltages.

Static frequency converters use mercury-arc rectifying devices in special circuits to supply high-frequency, high-power loads such as those encountered in induction heating.

Another static type, designed expressly for high-cycle lighting, consists basically of saturating transformers, capacitors and dry rectifiers. Outputs are rated approximately 25 amps, 700 volts at 360 cycles.

Phase conversion may be accomplished by rotating machines or static phase converters that utilize transformers and capacitors in a special circuit. These units allow operation of 3-phase motors from a single-phase supply. Various types are available for interchangeable operation of single-phase, 2-phase and 3-phase equipment.

Voltage regulators, when installed in an electrical circuit, improve efficiency and stabilize voltage and other circuit characteristics to meet specific requirements. Voltage regulators in use today include the induction type, step load-ratio type, the constant-voltage transformer, the saturable reactor, and a new autotransformer type.

Selection of the particular type that best meets a specific application depends on the basic circuit considerations (percent regulation required, magnitude and variation of input voltage, kva and the like). Other important considerations include location (indoors, outdoors, or pole-mounted); ambient temperature; size and weight; overload capacity; waveform; auxiliary devices and equipment; and cost.

The induction type operates on the principle of transformer action of a rotating secondary coil which adds or subtracts to the line voltage as required. This type is available for single-phase operation at ratings up to 240 kva and at stand-

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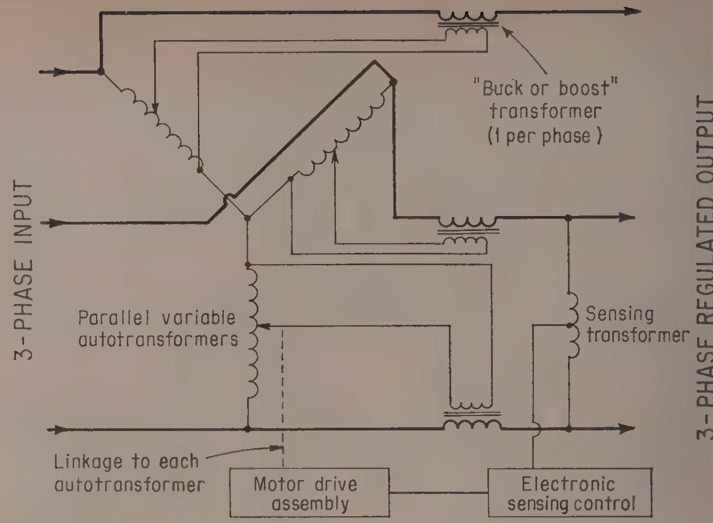
ard voltages up to 7500 volts. Many units provide plus or minus 1% voltage regulation. For 3-phase applications, units are rated up to 500 kva and can be used at voltages up to 13 kv.

The step load-ratio type regulates voltage through a tap-changing mechanism that may be manually or automatically controlled. Standard ratings are similar to those for the induction regulator; however, the step regulator is more suitable for higher voltage and kva ratings. Typical ratings range up to 2500 kva and up to 69 kv.

For small loads up to about 10 kva, constant-voltage transformers can provide plus or minus 1% voltage regulation. The waveform output of this type is often distorted; however, filters can be added to improve this.

Saturable reactor units are often used as voltage regulators for process control. Power ratings range up to 1000 kva, single phase; 3000 kva, 3-phase. They can be used on voltages up to 15,000 volts. This type requires a separate dc supply.


"Buck or boost" transformer (1 per phase)
3-PHASE INPUT
3-PHASE REGULATED OUTPUT
Parallel variable autotransformers
Sensing transformer
Linkage to each autotransformer
Motor drive assembly
Electronic sensing control

VARIABLE-AUTOTRANSFORMER voltage-regulator circuit arrangement is shown in diagram. When a voltage deviation occurs, the sensing transformer sends a signal to the electronic controller which operates the motor-drive assembly. Linked to the motor assembly, banks of paralleled variable autotransformers supply a compensating voltage to the exciting windings of "buck or boost" transformers, which then add or subtract to the line voltage as needed.

A new autotransformer type uses parallel banks of motor-driven variable autotransformers which excite "buck or boost" transformers. This type does not affect waveform or power factor. Other advantages are that it can regulate voltage to 1%, is comparatively light and can be constructed for high kva ratings.

Power capacitors are used in electrical systems to correct power factor and to reduce voltage drop. Because the most effective location to install capacitors is near the load, low-voltage units (230, 460, and 575 volts) are available rated from about 0.5 kvar to 25 kvar.

For high-voltage applications, primary capacitors may be installed in outdoor enclosures, open racks or atop poles. Standard ratings are 15, 25, and 50 kvar at voltages ranging from 2.4 to 13.8 kv.

When connected in banks, power capacitors can supply large blocks of reactive power. These units are available in dust-tight and water-tight forms.

POLE LINE EQUIPMENT

Selection considerations relating to poles, crossarms, insulators, anchors, and hardware are as follows:

Wood poles are usually selected for low- and medium-voltage distribution systems because they have strength, are comparatively light, have durability, and are abundant at moderate cost. When long life and appearance are important, steel or concrete poles can be used.

Wood-pole specifications have been standardized by the American Standards Association. The standard specifies that all poles be free of cross breaks, sap rot, bird holes, plugged holes, damage from marine borers, and similar defects.

Certain defects are permitted including: checks and splits in butts, insect damage, knots, defective butts due to splinter-pulling in felling the tree, slight curvature of the pole along its length.

Pole classifications are based on the circumference at the top of the pole and the circumference at a point 6 ft from the butt. There are ten classes designated Class 1 through Class 10. For each class, circumference specifications depend on the length of the pole and type wood.

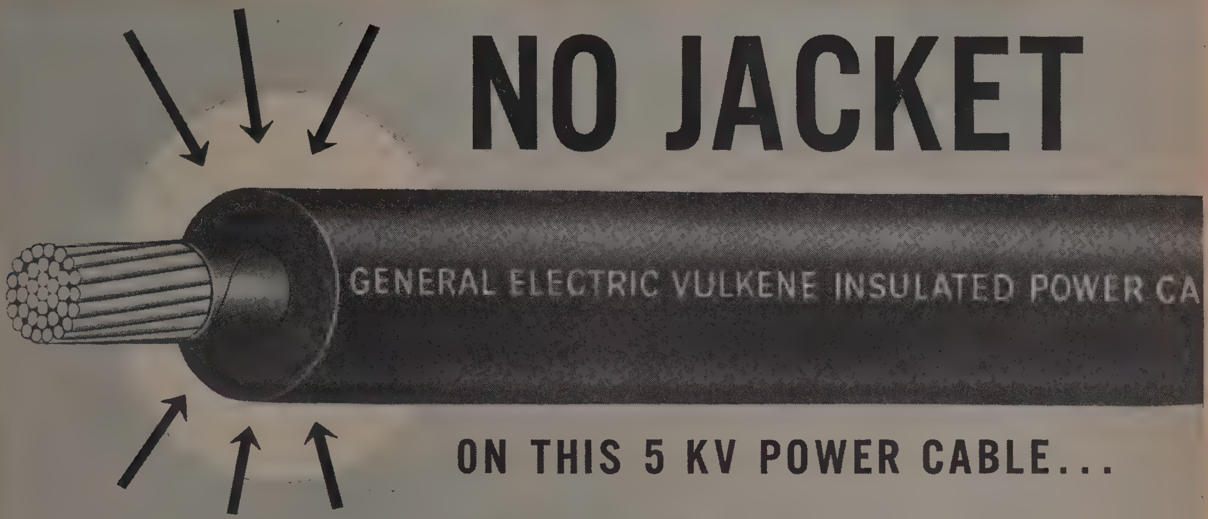
Coded identification is generally required on wood poles. Either branded or stamped on the wood, the code indicates type of wood, type of preservative, class number and pole length. In addition, code numbers may be present designating supplier and year of treatment.

Size of the pole selected depends on a number of various factors. These include: municipal ordinances, interference from trees, clearances required over highways, sidewalks and railroads, and number of wires and crossarms to be installed.

Crossarms most generally used are made of treated yellow pine or Douglas fir. Typical crossarms will vary between 4 ft and 10 ft in length with various cross sections

FOR THE FIRST TIME!

NO JACKET



ON THIS 5 KV POWER CABLE...

BECAUSE IT'S VULKENE* INSULATED!

No jacket on these thermosetting-insulated unshielded power cables, 600 volts or 5 kv, is just one of the features of General Electric's new line of Vulkene insulated power cables. There are plenty more.

Vulkene is a new thermosetting insulation developed by General Electric in its search for an ideal general-purpose insulation that would have the best properties of both butyl rubber and polyethylene.

They found the answer in Vulkene—a cross-linked polyethylene for which they were able to develop a precise method of compounding, processing, and extruding that produced the *proper balance* of properties needed in a superior cable insulation. It is this *unique* balance that differentiates Vulkene from ordinary cross-linked polyethylene.

IN VULKENE—THE BEST OF TWO

Years of testing in the laboratory and in actual use, have proved that Vulkene combines the excellent heat stability of rubber with the excellent electrical properties of polyethylene. That's why we are sure that whether you choose Vulkene power, aerial, or interlocked armor cable, you will get:

- Longer service life
- Greater current-carrying capacity
- Low electrical losses
- Easy handling because cables are smaller in diameter . . . lighter in weight
- A choice suitable for a wide variety of applications and for every type of environment
- More value from your cable dollar

We would like to send you test data, specifications, and other information on these cables so that you can compare the properties of Vulkene insulated power cables with other types available and see why we say that General Electric Vulkene insulated power cables obsolete all others. Just fill in and mail the coupon below.

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TABLE 1—GENERAL CLASSIFICATION OF WOOD POLES

CLASS	1	2	3	4	5	6	7	8	9	10
Minimum Top Circumference (inches)................	27	25	23	21	19	17	15	18	15	12

TABLE 2—TYPICAL REQUIREMENTS FOR 30 FT POLES

Type of Wood	CLASS									
	1	2	3	4	5	6	7	8	9	10
	Min. Circumference 6 ft From Butt (in.)									
Northern White Cedar.....	47½	44½	41½	38½	35½	33	30½	No Butt Requirements		
Western Red Cedar.......	41	38½	35½	33	30½	28½	26½			
Creosoted Southern Pine....	37½	35	32½	30	28	26	24			
Chestnut.................	40	37½	35	32½	30	28	26			

WOOD POLES are divided into Classes 1 through 10. Each class has a minimum circumference measured at the top of the pole as shown in Table 1. Different types of poles must meet minimum circumference requirements 6 ft from the butt end to qualify for a specific class designation. Requirements for a specific class also depend on length of the pole. Table 2 shows requirements for 30-ft poles.

ranging from 3¾ in. square up to 4 by 6 in. Size of the crossarm depends on conductor spacing and number of insulating pins to be mounted on the crossarm. To increase their useful life, crossarms are usually seasoned for at least three months and painted, or treated with a preservative, often creosote or pentachlorophenol.

To facilitate identification, crossarms may be marked or branded with code numbers which indicate whether the crossarm has received preservative treatment, or type of treatment applied, name of supplier, and year of manufacture.

In addition to wood crossarms, galvanized steel angle crossarms are also used on wood poles to obtain greater strength for supporting conductors.

Insulators of various types and sizes are used on pole assemblies to support conductors. Materials most commonly used for insulators are glass, porcelain or special compounds. Selection of an insulator of a particular material depends on various factors including voltage rating, dry and wet flashover values, puncture strength, mechanical strength, dimensions, and ability to withstand thermal shocks. For low-voltage applications, glass pin-type insulators can be selected. Porcelain insulators are better suited for high-voltage applications.

Common types of insulators available include: pin type, suspension type, strain type, and spool type. And within each group there are many variations.

Pin-type insulators, made of either glass or porcelain are furnished with a threaded hole through their centers to accept a mounting pin. The mounting pin is threaded on one end and may be made of either metal or wood. Recent trends favor the metal pin. Pin-type insulators are rarely used on voltages over 69 kv; however, modern units are available for use up to 138 kv.

Suspension-type insulators are used almost exclusively for high-voltage applications. Suspended from the bottom of the crossarm instead of mounted on top, this type can support heavy conductors over long spans.

These insulators are usually made of porcelain; however, a heat-resistant glass type is available with a reported very high tensile strength. Ultimate strength of porcelain insulators ranges from 10,000 to 17,000 lb.

In application, a number of these insulators may be arranged in a string to support high voltages.

Spool-type insulators are widely used on insulator rack assemblies (sometimes called secondary racks) mounted on sides of poles to support low-voltage conductors or to provide dead ending. In addition, they are used individually, mounted with small angle brackets or clevises.

Strain insulators, consisting of an assembly of high-strength suspension types, are often used for dead ending or terminating conductors. Double and triple strings mounted on a steel yoke should be selected for heavy conductors.

Strain insulators are also used in

Soil Classification Data

CLASS	DESCRIPTION OF SOIL
1	Solid Bed Rock
2	Laminated Rock; Slate; Schist; Sandstone
3	Shale; Broken Bed Rock; Hardpan; Compact Clay-Gravel Mixtures
4	Gravel, Compact Gravel and Sand; Claypan
5	Medium-Firm Clay; Loose Sand and Gravel; Compact Coarse Sand
6*	Soft-Plastic Clay; Loose Coarse Sand; Clayey Silt; Compact Fine Sand
7	Fill; Loose Fine Sand; Wet Clays; Silt
8**	Swamp; Marsh; Saturated Silt; Humus

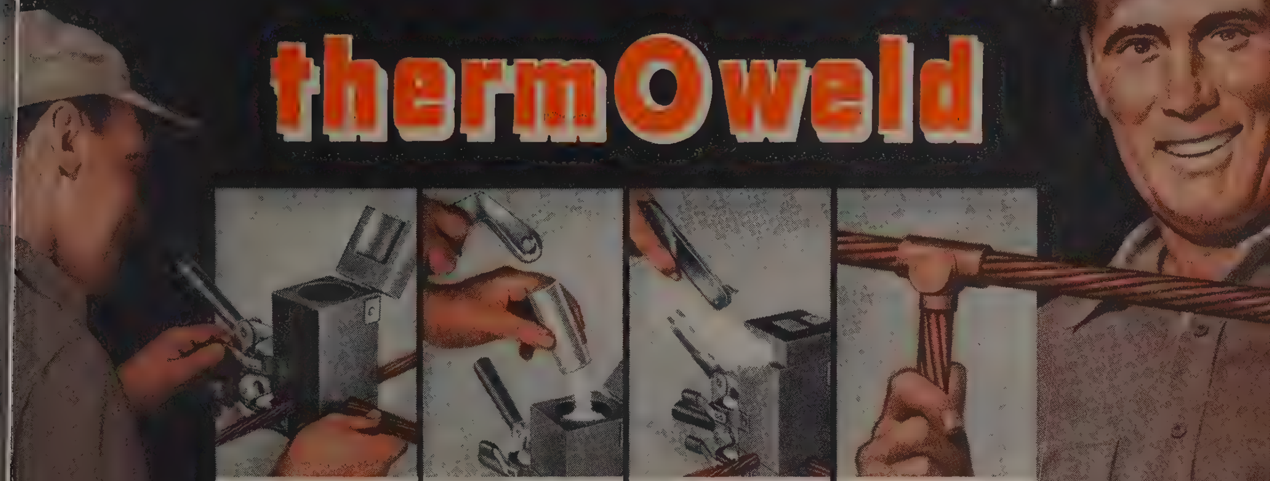
* Includes areas only seasonally wet with slow drain as in fairly flat terrain.

** Install anchors deep enough, by the use of extensions, to penetrate a Class 5, 6, or 7 underlying the Class 8 Soil.

SOILS have been classified to facilitate effective selection of anchors. Holding power of an anchor depends both upon its size and viscosity of the soil in which it is installed.

Only BURNDY offers all three!

THERMOWELD®—COMPRESSION—BOLTED



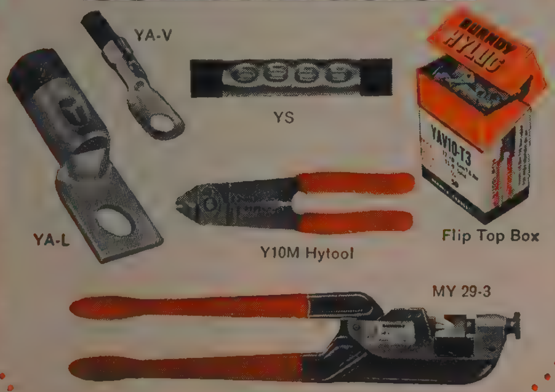
Weld anywhere with lightweight THERMOWELD. Self-contained, needs no external source of power.

Pour powder into mold, tap. Starting powder won't mix with welding powder, assures positive firing.

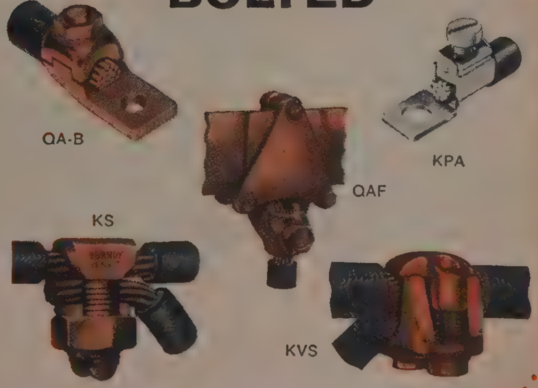
Close cover, ignite with flint gun. THERMOWELD forms liquid copper which fuses conductors into solid mass.

Welds a permanent electrical connection easily and economically to any copper conductor or steel structure.

COMPRESSION



BOLTED



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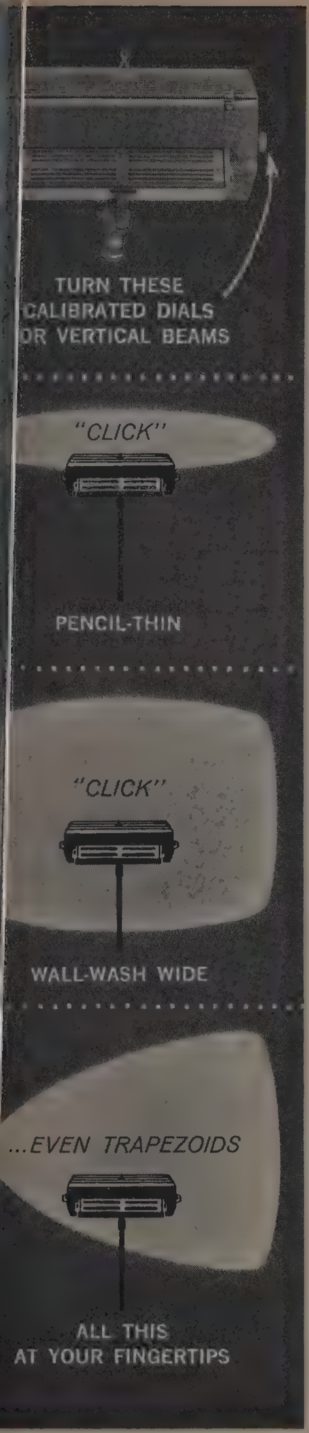


NOW YOU CAN ACTUALLY DIAL THE BEAM YOU NEED

Read about the Beam Selector and other exclusive features of this remarkable Stonco floodlight for quartz iodine lamps.

TOO MUCH SPILL-LIGHT

What can you do when the floodlights are up and some beams are spilling over? It happens even when lighting layouts are made with loving care.

You can re-order units with tighter beams. Tear down. Re-install. You can, but you probably won't. Too expensive. Besides, mistakes are inevitable. Since we can't change the inevitable, Stonco has improved floodlights instead.

We built an adjustable focusing device right into our fixture. A Beam Selector. With it you can actually dial the beam you need. On the job, if necessary. It's easy to do, yet very scientific. Like a zoom camera.

The results leave little to be desired. Layouts are virtually goof-proof. Coverage is just what you want [or change it until you are satisfied]. There are no complications. No special fixtures. No special reflectors. No special lenses. One floodlight does it all. Beautifully. But only with the Beam Selector.

WHAT IS PERMADITE?

Permadite™ is our name for a new kind of reflector. It is manifestly brighter and harder than any other reflector commercially available today. It has to be to withstand the hellish heat of a quartz iodine lamp without dulling, crazing, or just plain "burning up."

There's only one way to protect a reflector from such intense high heat, as well as ordinary corrosion. Thicken the anodic armor. Unfortunately heavy anodizing gets "hazy" on conventional reflectors, due to normal impurities in the base metal. So we start with purer aluminum. The trade has a name for super high purity aluminum: AL 99.99%. We call it Permadite because it's far more brilliant initially, and stays brilliant even when protected with a tough anodic coating thick enough to cloud ordinary reflectors.

Although the actual process is classified, we hope you'll remember the name Permadite and what it means for you: More light. Permanently.

WHO READS INSTRUCTIONS?

Hardly anyone. Which is why we take great pains to avoid elaborate instructions, and the work that accompanies them. For example, quartz iodine lamps must be operated within 4° of horizontal. Our answer is a built-in horizontal leveling device. Compensates for eccentric mounting.

How can you tell the fixture is level?

With a built-on bubble level. Right on top of the fixture where it's easy to see. Forever.

How do you aim the fixture?

With a built-on rifle-sight. Very convenient.

How do you service the fixture?

Through the back door. Rear re-lamping eliminates pole-top acrobatics.

What else? A heat, shock, and impact resistant wrap-around lens for less trapped light. External fuse chamber. Degree-marked vertical aiming quadrant. Arm-gripping locking teeth. And more, including mounting accessories galore.

SOMETHING FOR NOTHING

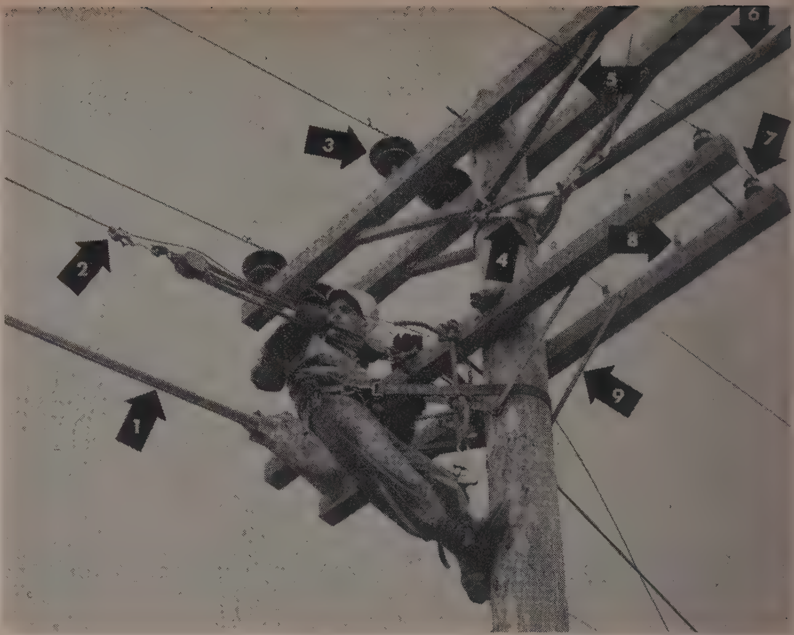
Does a floodlight have to look like an old metal kettle with a glass lid? We don't think so. To prove it we've added a bonus of beauty. The result is a fixture for quartz iodine lamps the likes of which you've never seen before. Frankly, a picture doesn't begin to do this beautiful die-cast aluminum floodlight justice. But if you drop us a postcard, we'll gladly arrange a private showing.

STONCO ELECTRIC PRODUCTS CO. • 333 MONROE AVE. • KENILWORTH, NEW JERSEY guy-wire assemblies to insulate the lower portion of the guy wire from the dangerous high voltages at the pole top. These types include a smaller unit usually made of porcelain which has a holding strength up to about 20,000 lb; a wood strain insulator is available with tensile strength up to about 35,000 lb.

Anchors are devices used to provide solid attachment of pole guy wires to the ground. They are available in a number of types which take into consideration the type of soil as well as holding power and strength of the anchor.

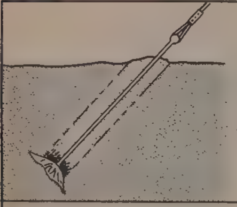
Expanding anchors are used for general anchoring applications. This type is a collapsible assembly of 2, 4 or 8 sections of steel plates. In the folded position the anchor is lowered to the bottom of an anchor hole. The plates are then expanded by taps on a tamping bar to force the assembly to spread wedging itself into the ground on the sides of the hole. This type can be selected for use in Class 3, 4, 5, 6, or 7 soil. Holding strength can range up to 40,000 lb in Class 3 soil using an expanding anchor with 12-in. plates.

Plate anchors are also popularly used for general anchoring. As its name implies, the plate anchor is a curved, rectangular plate of steel. Used in Class 3 to Class 7 soil, its holding power ranges from about 11,500 lb in Class 7 soil for a 6 by 17 in. anchor, to 50,000 lb in Class 3 soil for a 10 by 40 in. anchor. An advantage of this type is that its holding power does not depend on tamped fill-in earth. Instead the plate anchor pulls against solid earth.

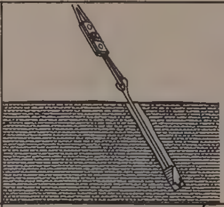


ATOP POLE, lineman draws in new conductor. Arrows point out (1) insulating sleeve, (2) cable clamp, (3) pin-type insulator (high voltage), (4) pole band, (5) wood crossarm braces, (6) wood guy-strain insulator with arcing horns, (7) pin-type insulator (low-voltage), (8) insulator pin, (9) flat steel crossarm braces.

Screw-type anchors can be selected for general anchoring and for anchoring in swamp areas where it would be difficult to dig an anchor hole. Consisting of a steel corkscrew-like blade and a shank with an eye at the top, the anchor can be quickly installed by twisting it into the ground by means of a bar inserted through the eye. In



EXPANDING ANCHORS are used for general anchoring. Size of anchors in folded position ranges from 6 to 12 in. diameter. Expanded sizes range from 50 to 300 sq. in.



ROCK ANCHORS are used for anchoring in rock, rocky soil or masonry. The expanding rock anchor is made of malleable iron, develops tremendous holding power through a wedging self-action.

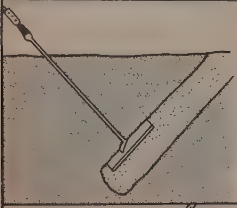
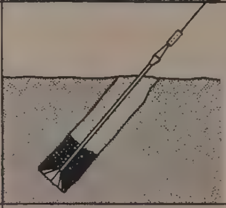
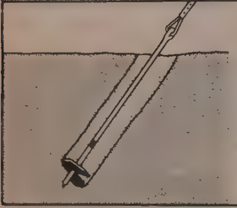


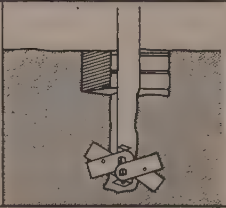
PLATE ANCHORS, also used for general anchoring, are made of malleable iron or steel plates. They provide excellent holding power because pull is against undisturbed earth.



CONE ANCHORS are made of steel and are used in class 2 through class 5 soil. Sizes range from 6 to 23 in. diameter. It develops adequate holding power in class 2 soil through wedging action.



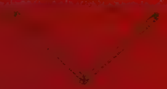
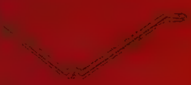
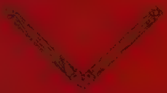
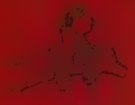
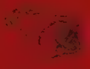
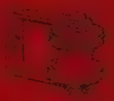
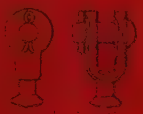
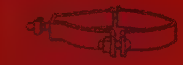
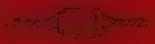
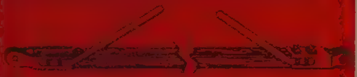
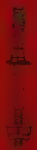
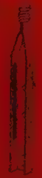
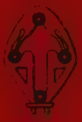
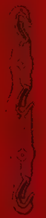
SCREW TYPE ANCHORS can be selected for general anchoring in class 4 to class 8 soils. The corkscrew-like blade is made of drop-forged steel. No anchor hole is required; anchor is screwed into the ground with a wrench or bar.



KEY ANCHORS, sometimes called pole keys, are used where standard guying is impossible because of sidewalks, property restrictions, etc. Additional keying is necessary at ground level.

BASIC TYPES OF ANCHORS are shown installed. Anchors may be hot-dip galvanized or black asphaltum dipped for longer life. Except for rock anchors, anchor rods are usually supplied separately. Rods and fittings should be high-strength steel, hot-dip galvanized. Copper anchor rods and fittings are also available.

Typical Pole Line Hardware

 Flat steel braces  Steel angle brace  Wood crossarm brace	**FLAT STEEL CROSSARM BRACES** are strong, sturdy and economical. They are supplied in 18 in. to 34 in. lengths. A ribbed type is available for severe strain applications. **STEEL ANGLE CROSSARM BRACES** provide high-strength bracing when transformers or other heavy equipment are to be carried. They are available in standard sizes up to a 72-in. span. **WOOD CROSSARM BRACES,** often used on high-voltage poles, are usually made of a dense wood such as fir, are pressure-treated for long life. Span sizes range from 42 in. to 86 in.
 Suspension clamp  Strain clamp	**SUSPENSION CLAMPS** are used in conjunction with suspension insulators to carry the conductor. **STRAIN CLAMPS** for large pole-line conductors may be the compression type or bolted type. All are available in forged steel, pressed steel, malleable iron, forged aluminum, cast aluminum and bronze.
 Flat steel clevis  Ball clevis	**CLEVISES** are U-shaped devices with many applications. **FLAT STEEL TYPE** is shown supporting a spool-type insulator. **BALL CLEVIS** is used in conjunction with suspension insulators.
 Pole band	**POLE BANDS,** usually made of 1½ in. by 3/16 in. steel, provide means of attaching guy wires, secondary racks, etc. to poles. Several types are available providing for continuous adjustment and multiple attachments.
 Porcelain guy strain insulator  Wooden guy strain insulator	**GUY STRAIN INSULATORS** may be porcelain or wooden furnished with arcing horns. The porcelain type is inexpensive and is made so that even if the porcelain fails, the supporting wires will interlock and will not fall. The **WOODEN TYPE** has high-strength and is used for high-voltage applications. Composition types and a new fiberglass type are also available.
 Forged-steel pin  Ribbed pole-top pin	**INSULATOR PINS,** used to support pin-type insulators, may be wood, steel, steel and lead, or steel and wood. Wood pins are least expensive and are often selected for low-voltage distribution. **FORGED-STEEL PINS** are often used for high-voltage applications. **RIBBED PRESSED-STEEL PINS** are used on pole tops.
 Plastic messenger spacer  Plastic vertical-line space	**PLASTIC SPACERS** provide for simplified installation and long life service. They eliminate need for nuts and bolts, provide for easy maintenance, and have neat appearance.

Class 8 soil, holding power ranges from 6000 lb for an 8-in. anchor to 15,000 lb for a 15-in. anchor.

Rock anchors are used for anchoring in rock, rocky soil or masonry. After a hole is drilled in the rock, the rock anchor is dropped in and its anchor rod turned to expand the anchor. Thereafter the anchor develops a tremendous holding power by a wedging self action.

Cone anchors can be used for general anchoring, but, in addition are used to gain effective anchoring in shale or loose rock (Class 2 soil). This anchor is simply a steel cone which is placed in the anchor hole and back filled.

Key anchors are used for anchoring where it is impossible to use a standard guy due to sidewalks, property restrictions and the like. Consisting of a collapsible assembly of two or four steel plates, the key anchor, sometimes called a pole key, is installed at the base of the pole in closed position. It is then expanded by tapping on the anchor shaft, causing its blades to unfold and gain holding power in the surrounding earth.

Hardware for pole-line equipment covers a very broad range of devices. In the accompanying table, typical forms of commonly used hardware are shown along with data pertaining to each type.

SECONDARY RACK, bolted to an angle-iron cross piece on transformer platform, has spool insulators which support low-voltage conductors supplying power to a trailer park.

Use no hooks on a Clark starter

This shape of screwdriver could be a handy maintenance tool for some AC motor starters, but not for Clark "CY" starters.

We don't put our screw heads behind, beneath, or around the corner from anything. Screwdrivers get an easy straight approach to all the service screws on a Clark starter.

Design advantages such as this one can mean a big money advantage when the productivity of men, machines and materials depends upon quick repair or parts replacement for electrical controls.

Check all makes when you buy or replace electrical controls. But compare all makes with Clark. Compare for quality construction, ease of installation and repair—for the design features that save time, trouble and money.

And, compare price. Clark controls cost no more. 6291

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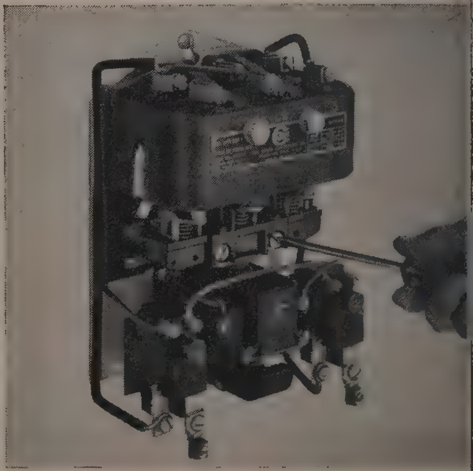
MAIN PLANT: CLEVELAND, 10 • WESTERN PLANT: LOS ANGELES, 58
IN CANADA: CANADIAN CONTROLLERS, LIMITED, TORONTO, ONTARIO



Unobstructed front accessibility of all screw heads, spring clips for quickest contact inspection, easy contact and coil replacement, and the industry's most effective arc quenching—all extra features of Clark Type "CY" starters, at no extra cost.

AUTO-TRANSFER SWITCHES

The automatic transfer switch is widely used in modern electrical systems to provide automatic transfer of an electrical load from normal to emergency supply upon failure of the normal supply. It will also restore the load to the normal feed when normal voltage returns.

Selection of an automatic transfer switch should be made according to the following considerations:

1. In either the normal or emergency position, the switch assembly must have sufficient continuous current-carrying capacity for the demand load connected to the load terminals.

2. The switching units must be capable of safely and efficiently handling the currents encountered in closing the load on the emergency supply when the normal supply fails and in disconnecting the load from the emergency when normal power returns.

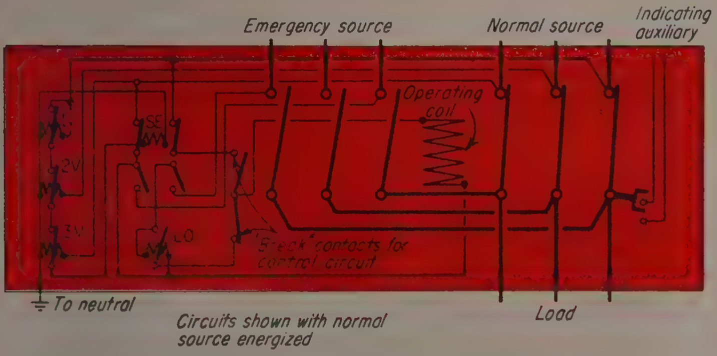
3. Switches must be rated to withstand the thermal and magnetic stresses of fault currents let through during the time it takes for short-circuit protective devices to clear faults.

4. Electrical- and mechanical-interlocking must assure against the possibility of the normal and emergency contact mechanisms being closed at the same time. And it must be assured that one or the other mechanism is closed depending upon the conditions of supply.

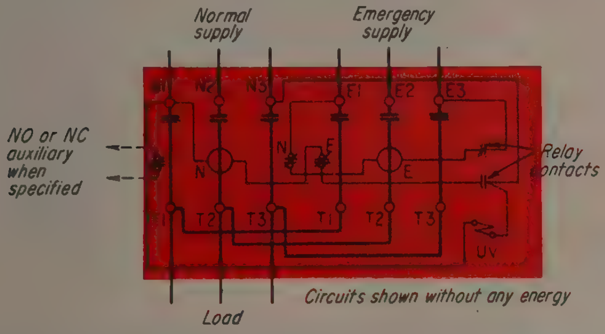
5. Protection against single-phasing of the normal supply or against excessive voltage drop should be provided in the control circuit of the switching assembly where load conditions require.

6. Proper time-delay characteristics should be incorporated in the control circuit to isolate the response of the assembly from transient voltage fluctuations in the normal system. Sensitivity to such fluctuations causes false operation of the transfer switch and may damage or destroy the starting circuit for the emergency generator. Cranking batteries, for instance, can be completely discharged by repetitive current demands over a short period, caused by a transfer switch responding to system transients and starting the generator on each voltage dip.

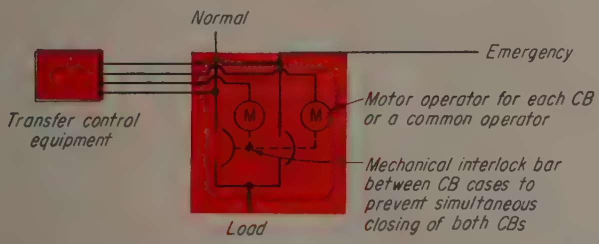
Basic Types of Automatic Transfer Switches



SINGLE-COIL, DOUBLE-THROW CONTACTOR with magnetic operation for either transfer, but mechanically held in either operating position. Relays 1V, 2V and 3V provide protection against any phase failure or voltage drop on one line. Relay SE is the circuit selector, and relay LO supervises emergency.



TWO SEPARATE CONTACTORS, mechanically and electrically interlocked to prevent simultaneous opening or closing. Undervoltage relay UV senses loss of normal power and initiates opening of NORMAL contactor. Availability of emergency power then closes EMERGENCY contactor. Each contactor has normally closed auxiliary contact in coil circuit of other contactor.


Normal
Emergency
Transfer control equipment
M
M
Motor operator for each CB or a common operator
Mechanical interlock bar between CB cases to prevent simultaneous closing of both CBs
Load

TWO SEPARATE CIRCUIT BREAKERS, mechanically and electrically interlocked, with a common operator or individual motor operators. Overcurrent (short circuit) protection is provided for both normal and emergency supply. Control panel may incorporate individual-phase supervisory relays and automatic starting and connection of the emergency generator or other source.

NOTE: Although different control circuit elements are indicated above for each of the three types of automatic transfer switching, any one of them may use any control circuit to accomplish desired response of the transfer assembly to conditions of the load, the normal source or the emergency supply. And a wide variety of control arrangements are possible for controlling the source of emergency power.

SIGNALS & COMMUNICATIONS

Signaling devices in common use today include bells, buzzers, chimes, horns, sirens, loudspeakers, in-out registers, and annunciators. Proper selection of one or more of these devices depends mainly on: purpose to be accomplished, type of occupancy to be served, noise level, and type of noise.

Purpose to be accomplished — Basic to the selection of a signaling device is its ultimate use. As an example, for general alarms use horns or sirens; for coded fire alarms select single-stroke bells or chimes; to monitor operation of equipment, audible signals plus signal lamps or annunciators are often the choice.

Type of occupancy to be served —The signal selected should fulfill its need without detracting from the decorum of the area served. In hospitals or residences, chimes, low-level buzzers, or mellow bells are usually suitable. In a noisy industrial shop area, however, sirens, horns or visual indication may be required.

Noise level — In an extremely noisy area, use a series of smaller signals rather than a few large units. For average noise-level offices or light-assembly areas, select buzzers, chimes or bells. In heavy-assembly areas or in light-machine shops, 4-in. and 6-in. single-stroke bells are often selected. Ten-in. single-stroke bells and 4-, 6-, and 10-in. vibrating bells are usually suitable for use in heavy-machinery areas or in punch-press rooms. Sirens and horns are effective in high noise-level areas.

Type of noise — Pitch of surrounding sound is also an important factor. In generator rooms, where a horn might blend with a humming generator, bells and visual signals should be selected. In a foundry or in areas where metallic noises may simulate a bell, horns or sirens are the better choice.

INTEGRATED ALARM AND PROTECTION SYSTEM performs a large variety of signaling functions in a large industrial plant. A single operator at the master console can immediately be informed of fire or smoke, detect intruders, listen-in on specific areas during non-business hours, monitor equipment operations, and control entrances via closed-circuit television and two-way intercom. Various "building block" subsystem panels can be incorporated to provide any number of desired signaling operations.

The following paragraphs describe pertinent features of available signaling equipment and present suggestions that will be helpful in attaining proper selection and application.

Bells come in a wide assortment of sizes, tones and styles. Both heavy-duty and light-duty units are available in 4-in., 6-in., 8-in., 10-in. and 20-in. sizes. For residential doorbell use, the 2½-in. or 4-in. size is usually suitable.

Bells are designed for either single-stroke or vibrating action. Vibrating bells ring continuously as long as current is applied. They are used primarily as alarm or time signals. Single-stroke bells are widely used for paging.

The bell mechanism may be equipped with electrical contacts which open and close the circuit to the rapper coil, or it may incorporate a resonant circuit which produces the oscillatory action required without electrical contacts.

Bells are designed to operate at specific voltages but usually operate satisfactorily at plus or minus 20% of rated voltage. Voltage ratings range from 3 to 15 volts, plus ratings of 24, 48, 115, and 230 volts. Bells are available for either ac or dc operation.

For outside use, weatherproof bells are equipped with a cast metal hood providing protection against rain, snow and ice.

Special type bells are available at all standard voltages for use in hazardous areas. These are either vibrating or single-stroke types utilizing the resonant circuit, contactless operating mechanism.

Bells can be flush, semi-flush or surface mounted. For flush mounting, wall boxes with knockouts and grille covers are available for all standard size bells.

Buzzers are often used for paging or indicating in stores, offices and apartment buildings, and for general alarms in public buildings or institutions such as schools or hospitals where sirens or horns would be out of place. Buzzers are available for operation at voltage levels ranging from 6 to 15 volts and at 24, 48, 115 and 230 volts. Light-duty or midget units serve garages, stores, residences or institutions where surrounding noise levels are low. Heavy-duty buzzers, capable of a higher sound output, find application in shops or areas where noise levels are not excessively high.

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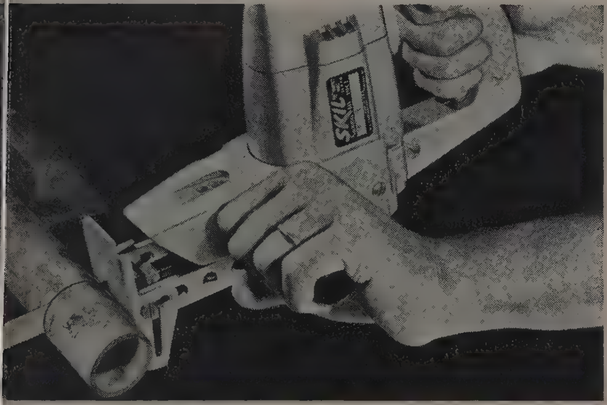
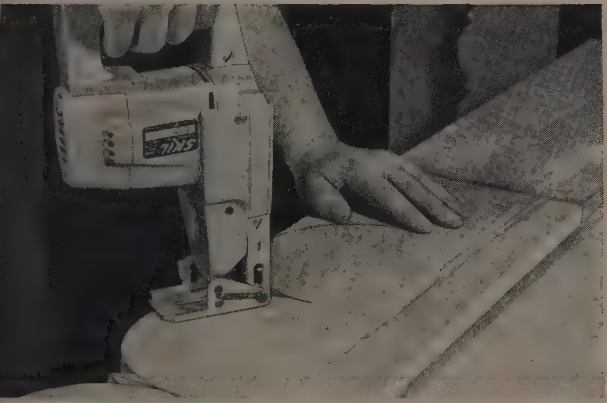
..and look at the jobs the new Skil Recipro Saw does!



Cuts metal—including pipe, conduit, tubing, angle, sheet metal, bar stock, aluminum, soil pipe and more.

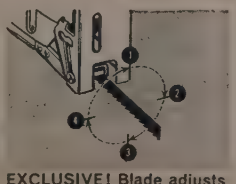
Cuts wood up to 6-inches thick (even with nails). Perfect for pocket cuts and notching work in joists and studding.



Cuts like a jig saw—makes intricate scroll cuts, pattern cuts and template cuts in wood, metal, plastic, etc.

Cuts where other saws can't for installing registers, junction boxes, heating ducts. Flush-cuts into corners.

NOW you can get a genuine Skil Recipro Saw (Model 577) *at one-half the cost* of other all-purpose saws. And with features of far more expensive models, including: double-reduction gears, a 4-position foot, 3-position handle, automatic sawdust blower, canted blade for faster cutting.



EXCLUSIVE! Blade adjusts for cutting in four directions.

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SKIL
POWER TOOLS

Downlights, pendants, chandeliers and stage lights in ballroom of Crestview Country Club, Wichita, Kansas — are varied as dramatically as in many theaters, with General Electric Remote-Control Wiring. Y club employees, from the youngest bus boy to th manager — find the system easy to operate.

"One flick of a switch changes whol G-E Remote-Control Wiring—at cost

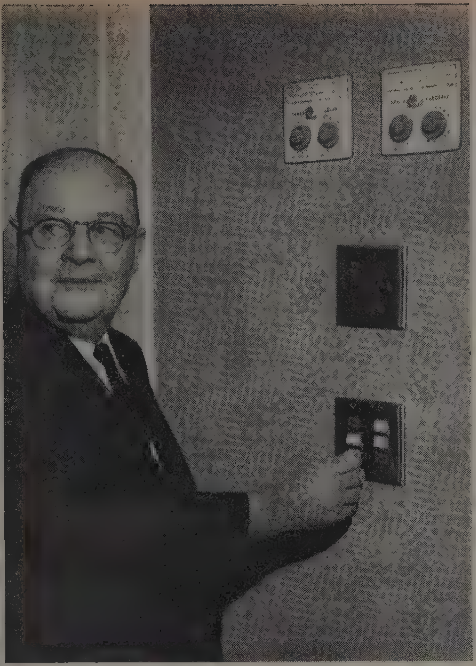
. . . says Carl Green, Consulti

"You just press the right switch to create any of four different lighting moods in this ballroom," says Mr. Green. "General Electric Remote-Control relays and motorized controls do the rest!

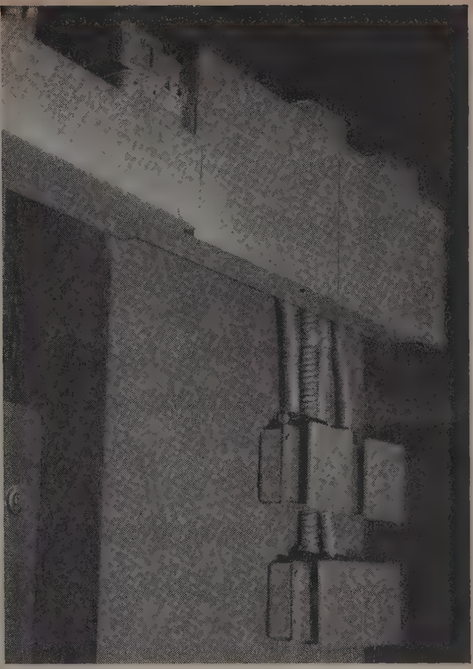
"Each mood varies the number, location or color of lights turned ON to suit dining, dancing, floor shows, etc. — and is put into effect by a 25-contact G-E Motor-Master Control. These contacts connect to the ON or OFF sides of low-voltage relays controlling all circuits.

"Pressing the mood switch activates one the Motor Masters, which sweeps its contact turn ON the lighting pattern and create desired mood.

"General Electric Remote Control helps give my customers theatrical lighting effect a fraction of the cost you might expect.



C. C. "Jack" Hall, the manager of Crestview, is delighted with convenient G-E "mood" switches (bottom). Other G-E switches (top) dial any or all circuits ON or OFF. (Middle switch is dimmer.)



Four General Electric Motor-Master Controls (lower right), relay boxes and 24-volt transformer (top) fit neatly beside panel, circuit breakers and dimmer in basement locker room.

G-E Remote-Control installation was part of complete modernizing job done on Crestview Country Club. *Architects:* McVay, Peddie, Schmidt & Associates, A.I.A., *Elect. Engineers:* Carl Green & Associates, P.E., *Elect. Contractor:* Southwestern Electrical Co., N.E.C.A.

hting moods with
rprisingly low"

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G-E 24-volt control wiring eliminates
ve switch loops. G-E Motor Masters and
eliminate big, expensive switchboards
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can offer better lighting control for less
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Carl Green

KEEP PACE ELECTRICALLY

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GENERAL ELECTRIC

Most buzzers are the contact type but contactless units are available for use in hazardous areas.

Buzzers may be supplied in cast housings with tapped outlets. Or they may be installed in a standard 4-in. box for flush mounting. Some models are equipped with an adjusting screw which provides for tone or loudness adjustment.

Chimes, because of their pleasing, musical tones, are often selected for door signals in residences and for coded paging in offices, hospitals, banks or other locations where noise levels are low. Units that provide one, two or three distinctive tones plus a melody are available for use in residences. Most models can be connected to indicate the signal origin (front door, service door, etc.). Most residential chimes operate on low voltage (10, 16 or 24 volts).

For paging, coded alarms, or scheduling, a more rugged, single-tone chime is usually selected. Units are available that emit various sound frequencies. Frequencies of 980, 490 and 245 cps are popularly used. Chimes are available for operation at 230 or 115 volts or at low voltage.

Horns and sirens have loud, attention-getting tones which make them particularly suitable for alarm signaling. Horns are often used for starting and dismissal signaling and sometimes for code paging. General types of horns include the vibrating type (low and high power) and the resonating type which is more powerful.

Sirens are the most powerful and attention compelling of all signals. Because of their great range and high pitch, they are particularly suitable for alarm signaling both indoors and outdoors where noise levels are high.

Motor-driven sirens, supplied at either 115 or 230 volts, are rated in horsepower. Common sizes are ¼, ½, and 1 hp.

Loudspeakers are available in two basic types, horn speakers or cone speakers. Made of metal in the form of a flared trumpet, horn speakers have a very high sound output. They are usually the choice for outdoor applications — playgrounds, stadiums, etc.—and for indoor use to cover large areas—auditoriums, high-bay areas in plants or warehouses, etc.

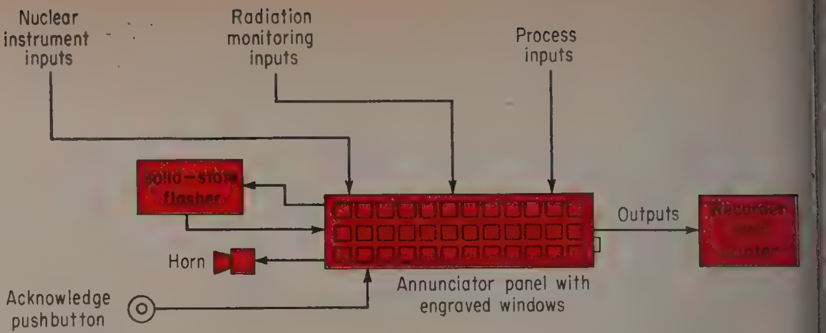
Nuclear instrument inputs
Radiation monitoring inputs
Process inputs
Solid-state flasher
Outputs
Horn
Acknowledge pushbutton
Annunciator panel with engraved windows

DIAGRAM OF A COMPLEX, solid-state annunciator system for a nuclear reactor shows basic components. Annunciator panel may have hundreds of windows to indicate vital information. Thousands of points may be monitored by means of the recorder-printer and solid-state flasher which indicates when a specific point trips the alarm circuit.

Cone speakers consist basically of a voice coil, magnet and a pressed paper saucer-like diaphragm. Because they are capable of clean, faithful reproduction of sound, cone speakers are preferred for use in music distribution systems. Although they lack the long distance penetration of horn speakers, their characteristics are ideal for paging and music reproduction when general noise level is not high.

When selecting a loudspeaker many important factors must be considered. Among them are: surrounding noise level, power capacity, volume control at speaker, baffling requirements, dimensions and mounting, need for line-matching transformer, and frequency response.

Annunciators come in a wide variety of styles with various optional features depending on application. Basic components include: visual indicators (lamps or gravity drops), audible signals, control relays mounted integral with the annunciator or in a separate panel, remote pushbuttons for signaling, or remote actuators such as thermostats, float switches, or any device that will break an electrical circuit.

For use in large homes, offices, small hotels and motels, annunciators with as little as four windows can be selected. Optional features include manual or electric reset, audible signal, and ring-back or call-back provisions.

Highly sophisticated systems, which can monitor as many as 10,000 separate points, are available for industrial use.

Depending on requirements and level of reliability needed, desirable features include: self-supervision to indicate any malfunction of the annunciator itself, plug-in relay units for easier system troubleshooting or expansion, test circuit, remote ring-back or intercom in large installations. In special instances, recording equipment may be added.

In-out registers find extensive application in hospitals, offices and industrial plants. Equipment includes one or more entrance registers; an operator's register panel, which is usually desk mounted; and a transformer to supply low voltage to indicating lamps. A flashing unit may be added to inform an individual at the register panel that he should call the operator to receive a message.

A comparatively new system uses dial registers, solid-state storage center, and one or more "in-out" indicating units. As an individual enters or leaves, he will press an "in" or "out" button and dial his code number at a dial register located at the building entrance. This information is sent to the storage center located in a remote area. When operators wish to know if an individual is in or out, they will dial his code on the central indicator unit. The storage center then transmits the required information by lighting the appropriate "in" or "out" lamp on the indicator. Provisions are available for message or call-in indication, verification of dialing, and intercommunication.

Fire alarm systems consist basically of: alarm-initiating devices, audible or visual alarm signals, and a control panel which may perform special functions. Alarm-initiating devices may be manual or automatic. Manual initiating devices (sometimes called stations or fire boxes) are of two types, coded and non-coded. Because warning and evacuation is the primary consideration in factories, offices and schools, the non-coded system using non-coded stations is often selected.

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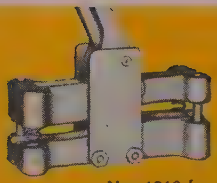
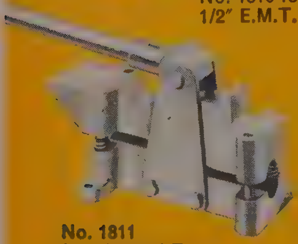


No. 1810 for 1/2" E.M.T.



No. 1811 for 3/4" E.M.T.

Now you can eliminate the need for costly offset connectors wherever ¾" or ½" E.M.T. is used in exposed installations. The new Greenlee "Little Kickers" save you up to 12c in material per connection . . . and cut hours off every job.

Both "Little Kickers" are in stock at leading electrical and industrial supply houses.

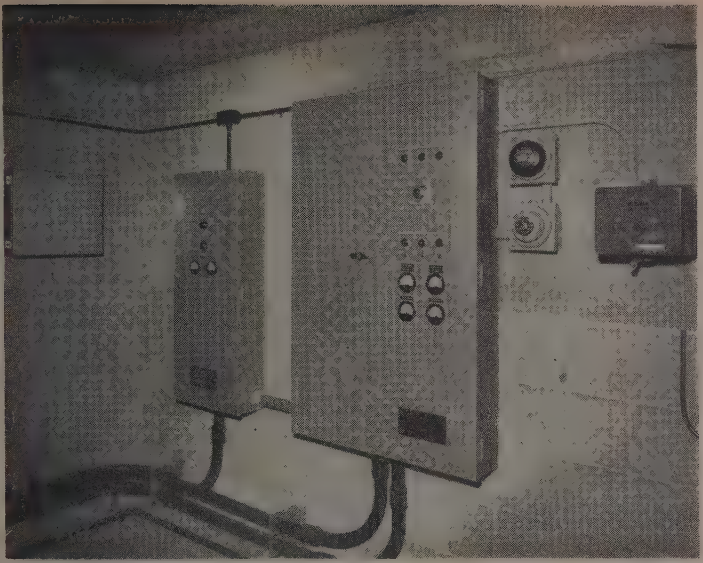
Order NOW.

TOOLS FOR CRAFTSMEN
GREENLEE

ANOTHER NEW ADDITION TO THE GREENLEE LINE OF JOB-PROFIT TOOLING

OUR 100th YEAR

GREENLEE TOOL CO., 2018 Columbia Ave., Rockford, Illinois



FIRE ALARM SYSTEM control cabinets provide for 3-zone fire protection in an industrial plant. Cabinet on left monitors one zone; larger cabinet in center protects two zones. Installation incorporates rate-of-rise combination fire detectors, coded fire alarm boxes, coded alarm bells, and supervisory trouble bells. Trouble bells can be seen at right of large cabinet. On the far right, an alarm box immediately transmits fire alarm to the local fire department.

For hospitals, hotels or institutional buildings, a pre-signal coded system is usually more desirable. This system allows staff personnel to investigate the pre-signal alarm and, if necessary, prepare for an orderly evacuation before sounding a general alarm.

Stations are available with or without break-glass provisions. (It is thought that the break-glass type tends to discourage false alarms.) Stations may be equipped with lock and key provisions for silent or coded testing.

There are several types of automatic initiating devices on the market. Most popular is the spot type, which is available in two forms, the fixed-temperature type and the combination fixed-temperature rate-of-rise type. Fixed-temperature units, usually set at 136° or 165° F for most areas, are effective over 400 sq ft mounted on 20-ft centers. Combination units cover 2500 sq ft on 50-ft centers. Both types may be mounted on a standard 4-in. octagonal box.

Other useful automatic initiating devices include photo-electric equipment to detect smoke in air ducts or in areas where smoldering fires may occur and infrared detectors which operate upon detecting flame, rejecting other infrared light sources.

Audible or visual signals for fire alarm systems include horns, sirens and bells for general alarm; single-stroke bells, chimes, buzzers and annunciators for pre-signal or coded systems.

The central control panel functions will depend on the type of system selected. In any case, the panel should incorporate an electrical supervisory circuit which sounds a trouble alarm if a fault should occur in the system components or wiring.

Fire alarm systems specifically designed to protect homes incorporate essentially the same equipment as those described previously. Operation is usually at low-voltage and provisions are made for automatic throw-over to a battery supply. In addition to sounding a general alarm, some home systems provide for visual indication of location of fire and for testing.

Intercommunication systems include both telephone and loudspeaker systems. When a great number of stations are required or where privacy is important, telephone systems become especially practical. On the other hand, loudspeaking intercom systems are often selected for normal inter-office communications where the number of stations rarely exceeds 60 and when immediate contact is essential.

Equipment for a loudspeaker intercom system includes one or more master stations and one or more remote-speaker stations. Consisting of an audio amplifier, selector switches and loudspeaker which also functions as a microphone, the master station can call any remote station and may be equipped to perform special functions. The remote station can call and receive messages from the master station but usually cannot call other stations. However, provisions are available for mixed intercommunication service.

Power, size and complexity of the master station will depend on the number of remote stations required, mode of operation, and optional features desired. For home and apartment building intercommunication, master-station power output may be as little as one watt. In large office buildings or in industrial plants, the master station may be rated as high as 10 watts.

Needs of the users will dictate which optional features will be included. Many systems on the market provide for audible and visual call annunciation, privacy call, priority call, paging from all stations, telephone-type handset and provisions for recording messages.

Home systems may incorporate AM/FM radio distribution, built-in door chimes, privacy control, and provisions for an integrated fire-alarm system.

Transistorized intercom systems are available with the inherent advantages of long-life transistors, low-power consumption, cool operation and instant communication.

Also available are carrier-current intercom systems which do not require control wiring but use existing power lines. In these systems, audio is carried on a high frequency which is coupled to existing power lines via a capacitor circuit and decoupled similarly at the remote station.

Telephone intercommunication systems provide for: privacy, rapid-communication in large systems, selective talking and ringing, and frees regular phone system to receive outside calls.

Equipment required includes telephone units (selector or dial type), operator's switchboard or automatic relay panel, and a power supply or batteries.

Many attractive styles of telephones are available including desk, wall or weatherproof units. One type incorporates earpiece, mouthpiece, and dial in an integral free-standing unit.

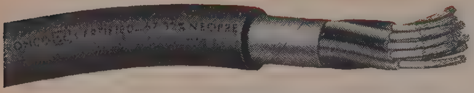
One man operates U. S. Borax & Chemical Corporation conveyor at Boron, California.

FOR THE **DEPENDABILITY** REQUIRED BY AUTOMATED INDUSTRY

...a multi-conductor cable for every type of installation—mobile or stationary, in ducts, conduits, trays, troughs, direct burial, aerial suspension, high temperature...

Virtually all of your control cable requirements can now be met by Bronco. Data given here indicates range of sizes shown in the new Bronco Control Cable Catalog, the sizes usually found in the very extensive stock carried in the Bronco network of Servicenters. The extraordinarily complete and versatile facilities for the manufacture of multi-conductor cables established by Bronco can handle your most unusual requests—mixed sizes, short and long lengths, combination power and control cables, shielded sub-assemblies...What's the maximum number of conductors? Ask. Give us the a.w.g. size, we'll reply by return wire.

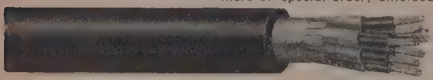
NEOPRENE



TYPE SO PORTABLE UL approved

BRONCO Certified 66

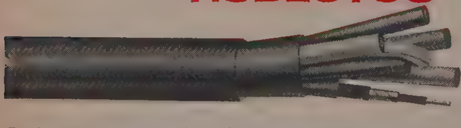
Extra flexible, fine-stranded conductors insulated with color-coded SBR rubber with an outer protecting jacket certified to contain not less than 67.32% neoprene. Branded jackets with all identifying information molded in so it won't rub off. Sizes 18 through 10 with from 5 to 60 conductors, more on special order. Shielded type also available.



STATION

Coated copper conductors either solid, coarse, or medium-fine stranded with a color-coded neoprene coating over each, a branded heavy neoprene outer protecting jacket. Sizes 14, 12, 10, 9, up to 37 conductors.

ASBESTOS

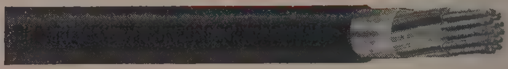


TYPE AVA

For temperatures up to 110°C (230°F) Bronco makes AVA control cable with coarse- and fine-stranded conductors insulated with asbestos and varnished cambric, color-coded cotton braid, covered over all with a closely-woven, impregnated asbestos braid. Sizes 12 and 9. 1 to 19 conductors.

NEW BRONCO CONTROL CABLE CATALOG is now off the press, write for your free copy.

PLASTIC



BRONC-hide (Pb) stabilized with lead

GENERAL PURPOSE FLEXIBLE THERMOPLASTIC

PVC (polyvinyl chloride) insulation and PVC jacket, flexible-stranded copper conductors, brightly color-coded, 600 volts, sizes 18 through 10 with up to 40 conductors.

I.M.S.A.

Bronc-hide 600 volt Municipal Signal Control Cable has solid copper conductors, is made in four types: with either polyethylene or PVC insulation, with a PVC jacket of either normal thickness, or extra-heavy for direct burial. Sizes 14 and 12 with 3 to 12 conductors.

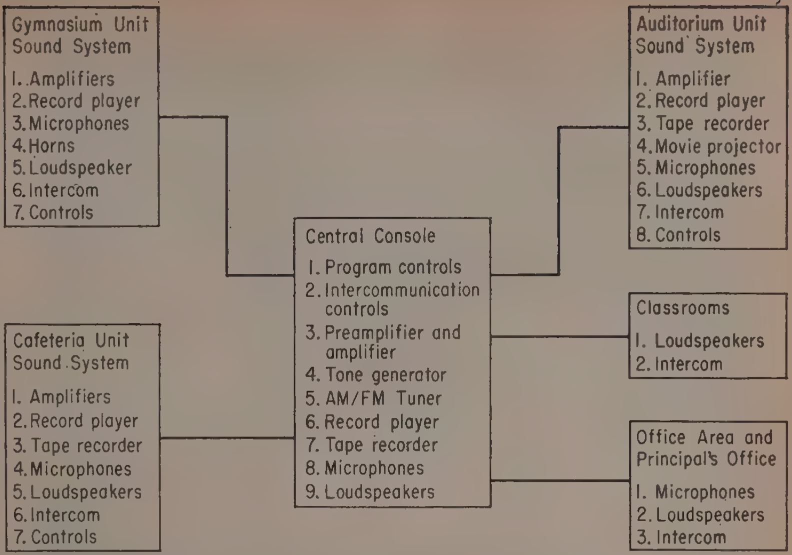
PNB

Bronc-hide PNB is a small diameter cable for operating temperatures from —40°F to +167°F. Flexible-stranded, coated copper conductors have polyethylene insulation covered with nylon, a PVC jacket over all. Stock sizes are 14, 12, and 9 with from 1 to 19 conductors.

BRONC-hide Thermoplastic Station Control Cables with 19-strand flexible conductors are made in a complete range of sizes in two types—1000 volt with polyethylene insulation and PVC jacket; 600 volt with PVC insulation and PVC jacket. Bronc-hide 300 volt telemetering cable with paired, solid, bare copper conduc tors are made in sizes 22, 19, and 1 with up to 50 pairs.

25th ANNIVERSARY 1962 **WESTERN INSULATED WIRE COMPANY/ LOS ANGELES 58, CALIFORNIA**

A QUARTER CENTURY OF SERVICE TO INDUSTRY SELLING NATIONALLY THROUGH ELECTRICAL WHOLESALE DISTRIBUTORS



BLOCK DIAGRAM shows a typical modern sound system for a large high school. The separate unit sound systems may operate independently or in conjunction with the main system. An all-call switch at the central console overrides all unit systems, so that special or emergency announcements can be made through all speakers. Other central console controls include volume controls, input selector switch, tone controls, intercom selector switches and an annunciator panel.

Ringing and talking connections may be handled by an operator at a switchboard or by an automatic relay panel. Functions provided may include absolute privacy, party lines, provisions for paging from any phone, priority provisions, and direct lines.

Nurse call systems consist basically of bedside calling station, corridor or bedside indicators, annunciator, and a transformer to supply low voltage. Some systems incorporate intercommunications or closed-circuit television as well as other special functions.

The two basic types of calling stations are the locking-button type (usually used with low-voltage systems) and the cord toggle switch type used on 115-volt systems. When a calling button or switch is operated by a patient, an audible signal will sound at the annunciator which indicates the origin of the call. Also, the call may illuminate a corridor lamp over the patient's room or, in a ward, a bedside lamp. The nurse may silence the audible signal at her station, but the visual indicators can be extinguished only by resetting the call button or switch at the patient's bed.

Most call buttons are supplied with a detachable cord which is plugged into a special wall receptacle. Call stations may be equipped with various features such as TV and radio outlets, emergency call and luminous buttons.

For use in operating rooms, an explosion-proof, foot-operated unit is available. And for use outdoors, a weatherproof unit can be selected.

Annunciators and intercommunication equipment should have functions and basic features similar to those described previously under their particular headings.

Clock and program systems provide for accurate timekeeping and for operation of bells, buzzers or relays according to a preset schedule. These systems are used extensively in schools but also find wide application in hospitals, commercial buildings and industrial plants.

There are four types of clock systems available:

1) A synchronous motored master control system incorporates a master clock that corrects each secondary clock each hour. A rectifier and transformer unit is required to provide low-voltage dc.

2) The minute-impulse system has a master clock and secondary clocks which are equipped with drive magnets to advance the clock hands. Each minute the master unit sends an impulse to all clocks causing the drive magnet to advance the clock hands one minute with every pulse. This system operates on low-voltage dc.

3) The dual synchronous motored system has no master clock but instead all clocks have two motors, one for normal operation and the other for correcting time after a power interruption. This system usually operates at 115 volts ac.

4) Electronic-controlled synchronous clock systems require no interconnecting wiring. Instead each clock is connected to any 115-volt ac circuit. In this system, coded high-frequency pulses from the master clock or transmitter are superimposed on the 60-cycle lines and are sensed at each clock or program device by special circuitry. Hourly time correction and power

COMBINATION CALL BUTTON allows patient to change channels on TV set, adjust volume, and listen to TV sound through pillow speaker without disturbing other patients. The device also functions as a nurse call button.

NURSE CALL panel, flush-mounted, includes audible signaling and annunciator visual signaling. Nurse may initiate calls or reply to calls from any patient on the floor. Note combination of conventional intercom and telephone handset at left of panel.

failure correction are also available with this system.

Program systems are often incorporated with clock systems to sound audible signals or to start or stop selected equipment automatically at a preset time. The program control panel will usually consist of a calendar drum or device, a time drum, signal-circuit relays, program-circuit pushbuttons and control switches.

Sound systems vary considerably in components, function and operation depending on the purpose they serve and the type of occupancy or location.

After the general requirements for a particular sound system has been defined, careful consideration should be given to the system components which include: types of inputs (microphones, tuner, record player or tape recorder), control center, amplifiers, and loudspeakers. A tone generator is often included to sound alarm or time signals.

There are three basic types of microphones: carbon, crystal and dynamic. The carbon microphone is almost never used in commercial sound systems and should be rejected as a possible choice.

The crystal microphone, a high-impedance type, provides excellent performance and is quite economical. It has wide application but should not be used where excessive heat is prevalent or outdoors in mid-summer. Because the crystal microphone is a high-impedance type, it should be operated within 50 ft of the amplifier. Operation beyond 50 ft will cause high frequencies to be attenuated and allow unwanted hum or noise to be picked up.

The dynamic microphone is probably the most popular type in use today for commercial sound systems. Its advantages include ruggedness, wide frequency response, moderate price and availability with either high- or low-impedance output. Some high-impedance dynamic microphones are equipped with a small switch that allows selection of either high- or low-impedance output as desired.

For highest quality performance, the velocity or ribbon-type microphone can be selected. This type should not be used outdoors and is more costly than the other types.

Microphone sensitivity patterns must also be considered for proper application. Uni-directional microphones are sensitive to sound from only one direction and may be selected for auditorium, stage or theater work. For interviews, the bi-directional type is the logical choice. The omni-directional microphone, which is sensitive to sound from all directions, is suitable for group pick-up or round table discussion.

Record players available include the automatic type and the manual type. The automatic record changer is capable of quality performance and may operate for several hours without attention. The manual record player affords better performance but requires frequent record changing. For high-quality sound pick-up, a magnetic cartridge is preferred because it has a wide frequency response. Crystal and ceramic cartridges do not have as wide a frequency response.

Tape mechanisms afford the advantage of musical programming for several hours plus the added feature of local recording of programs, instructions or records. Since the program material is on tape, storage space is minimum.

AM/FM tuners installed in a sound system should receive careful consideration. Important features to investigate are: frequency response, sensitivity, distortion, hum and noise ratio.

Amplifiers for sound systems may be combined with a preamplifier, which increases low-level signals from microphones or record players. Important selection considerations include: power output rating; output impedance; frequency response; gain; power consumption; hum; input channels for tuner, microphones and record player; tone controls and mounting.

Paging system equipment such as microphones, amplifiers and loudspeakers were discussed under Sound Systems. It is important to note, however, that mobile public address amplifiers are available which can be powered directly from either 6- or 12-volt auto batteries. These units can also be equipped to operate on 115 volts ac. Also available is a transistorized amplifier designed expressly for mobile use.

Coded call systems, both visual and audible, find wide application in industrial plants, commercial buildings, schools and hospitals. A transmitting device sends impulses to all buzzers, bells, chimes or horns sounding the code message throughout the building. The individual, upon hearing his assigned code, will then call the central operator.

In hospitals, a visual annunciator is often selected as the indicating device. When an individual is paged, large illuminated numbers appear on the annunciator corresponding to the individual code. The annunciators are strategically located throughout the building to provide complete coverage.

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plied for the
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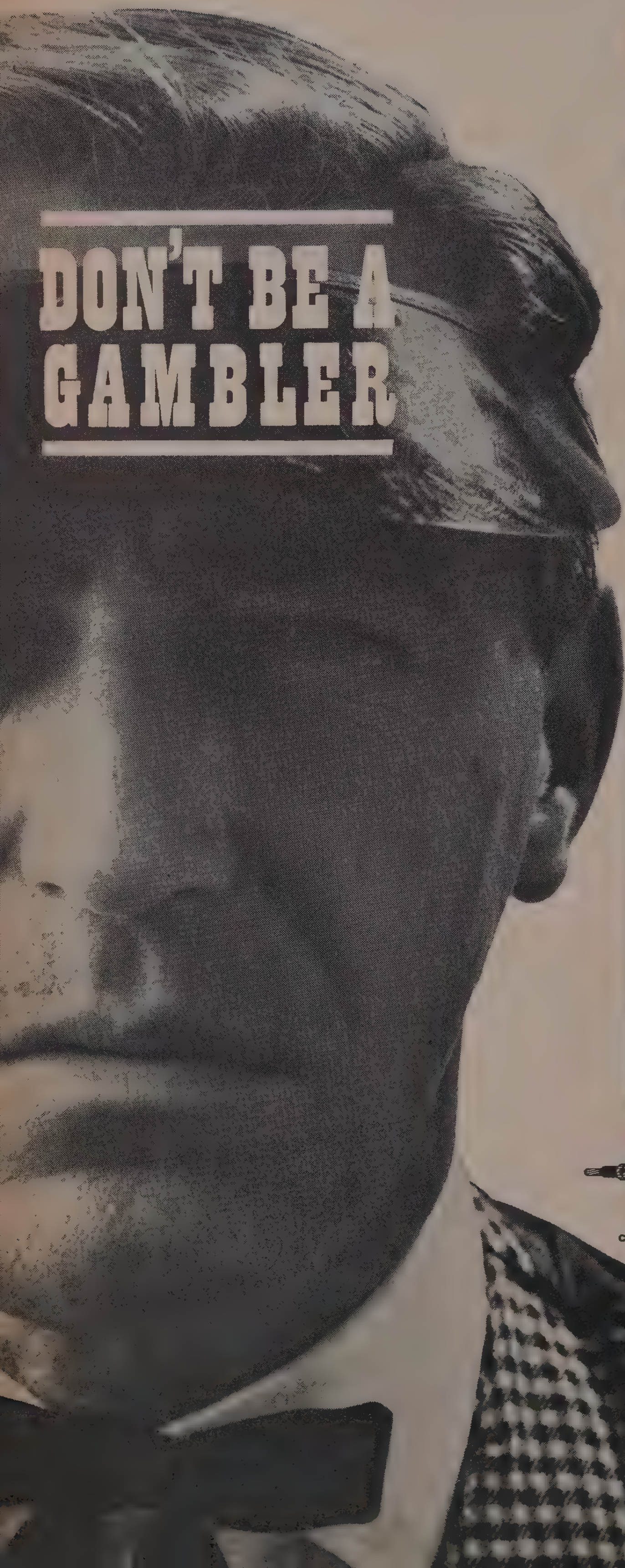
Since 1924 Westinghouse has continued improving the circuit breaker, with more improvements coming all the time

Since inventing the original AB molded case circuit breaker, Westinghouse has continued to earn scores of basic patents for circuit breaker developments. Each, in some way, has made today's Westinghouse circuit breaker a greater value. Present developments will make tomorrow's breaker even better.

These continued improvements have made Westinghouse AB De-Ion breakers the industry's most widely accepted breaker with designers, manufacturing engineers, contractors and others. Ask your local sales representative to show you how the full line of quality Westinghouse breakers can build more reliability into your electrical systems, or write Westinghouse Electric Corporation, Standard Control Division, Beaver, Pennsylvania. *You can be sure . . . if it's Westinghouse.*

J-30399

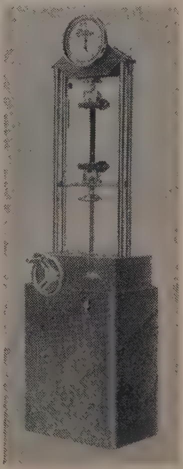
Westinghouse



Industry demanded it
Hatfield developed it

Tough cable installation job comin' up? Don't gamble! Get to know Hatfield "Hatflex" crush-resistant, non-metallic sheathed cable. It will save you plenty later! How?

Research developed "Hatflex" Cable eliminates long-standing faults often found in standard non-metallic insulated cables. The conductors are abrasion and crush resistant specially compounded PVC. They will not puncture or tear in installation. They save you labor and hard cash, too . . . there's no unwrapping necessary and that slashes time on the job and initial cost!



Here's the proof backing this performance. "Hatflex" was crushed by 1,800 lbs. of solid steel, between conductors, in a special compression cage – and it withstood the terrific impact without short circuiting or any insulation damage. The new crush-resistant, non-metallic insulating compound completely cushioned the full force! So, forget about insulation fraying or tearing even on your most rugged non-metallic cable installation challenge. Specify "Hatflex" and get the job done faster, safer, more economically.

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DIVISION OF CONTINENTAL COPPER & STEEL INDUSTRIES, INC.
Plants: Hillside • Union • Linden / Executive Offices: Hillside, N. J.

Product News

Transformers (1)

A new line of general purpose, dry-type transformers rated 25 va through 500 kva has been introduced. Units rated 30 through 500 kva have six universal voltage taps. The combination of four 2½%, full-capacity taps below normal, and two 2½%, full-capacity taps above normal, provides a 15% range of tap voltage adjustment. The new tap arrangement allows the industrial user to continue using the same transformer, even if a line voltage change occurs at a later date after installation. All of the transformers rated 30 kva and above are equipped with solderless, clamp-type terminals. They will accommodate either copper or aluminum cable. An improved insulation system design has been applied to transformers rated 100 va through 3 kva.

General Electric Co., Schenectady 5, N. Y.

Switches (2)

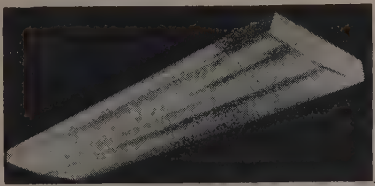
Ten new UL approved precision snap-action switches are offered for automatic limit, safety and interlock control in electrical circuits of industrial, commercial and household equipment. The devices feature small size, light weight, small movement differential and high electrical rating. They are available with solder lug terminals and bottom-facing screw terminals to accommodate up to No. 14 wire ring or spade connectors. A choice of actuator types and operating characteristics are available, with the actuators constructed as an integral part of the switch. All contacts are rated at 20 amps, 120 volts ac. Switches are both mechanically and electrically interchangeable with all other precisions snap-action switches.

Edwards Company, Inc., Norwalk, Conn.

Dimmer (3)

A new miniature electronic rotary dimmer incorporating such features as the ability to "gang" or "bank" as many units as is required, has been announced. The RDC-600 is supplied with a new "Fashion Rite" wall plate and knob. The Hi-Lux rotary dimmer can be mounted under any standard switch wall plate when desired. It is rated at a full 600 watts incandescent lamp load only.

Slater Electric Inc., Glen Cove, N. Y.



Lighting Fixture (4)

The new "Caravel" commercial fluorescent lighting fixture for surface or suspension mounting, has been introduced. The special "lift-and-shift" lens works from either end. Designed primarily for surface mounting, units are available in 2- or 4-lamp 40-watt rapid-start. The thin profile, 3⅛ in., allows unit to be used in almost any application for stores, offices and schools, while special diffuser eliminates brightness contrast in the illuminated areas.

Benjamin Division, Thomas Industries, Inc., 207 E. Broadway, Louisville 2, Ky.

Thermostat (5)

A new electric heat thermostat that can have its dial setting "set-back" approximately 15° by means of a remote switch has been introduced. The set-back feature makes these thermostats ideal for such applications as motels, hotels, schools, churches, hospitals and other multiple type structures which have limited periods of occupancy. The remote switches are located at one central location. The control also has a locking device whereby the dial can be locked at a specific setting or used to limit the range of dial temperature adjustment.

White-Rodgers Co., 9797 Reavis Road, St. Louis 23, Mo.

NEW
SIERRA
BIPLEX
GROUNDED RECEPTACLE

PAT. PEND.

Biplex is the name for this handsome new duplex receptacle that adds a touch of elegance to your projects —at budget prices! This grounded duplex matches the 2-wire Sierra Triplex and fits the same plates. Biplex is UL approved and meets all codes and standards.

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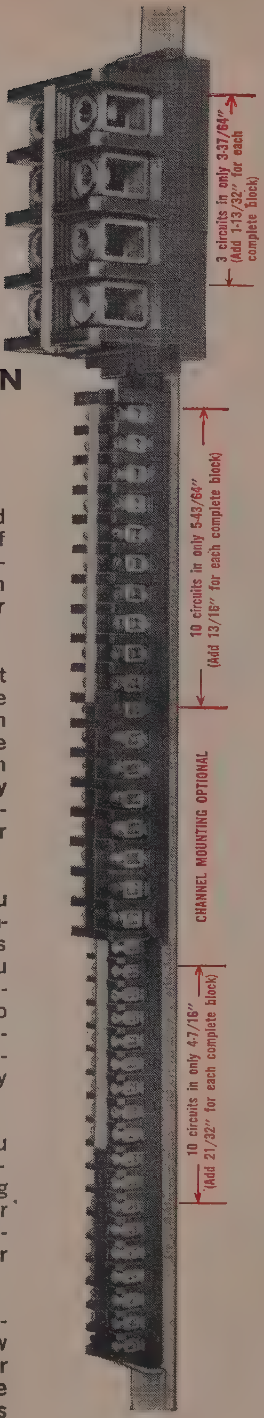
3 circuits in only 3-37/64"
(Add 1-13/32" for each complete block)
10 circuits in only 5-43/64"
(Add 13/16" for each complete block)
CHANNEL MOUNTING OPTIONAL
10 circuits in only 4-7/16"
(Add 21/32" for each complete block)

it's a snap . . .

WITH BUCHANAN SECTIONAL BLOCKS

Supplied in preassembled lengths . . . you snap-off the desired number of contact sections . . . add an end section . . . and your block is complete.

Buchanan blocks don't waste circuits. They reduce material and installation costs and save space. Three sizes cover from #22 through 250 MCM. Available in many contact and circuit identification types, flat base or channel mounted.

Buchanan blocks allow you to maintain a smaller inventory. You need only two parts for each size; this gives you increased production flexibility. Also, you have no loose contacts, bolts, washers, nuts or other miscellaneous hardware to worry about.

Buchanan blocks permit you to put more circuits in available space. Anchoring doesn't increase length or disrupt circuit spacing continuity. No space lost for intermediate mounting.

Buchanan blocks are completely covered in our new catalog B101. Write for your copy today. Learn all the reasons why so many users are turning to Buchanan . . . the best in blocks.

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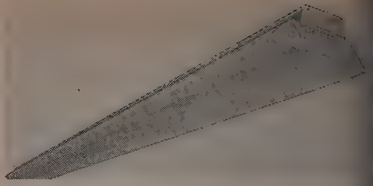
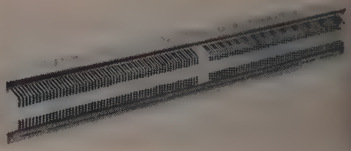


Fluorescent Fixture (6)

The 120-volt rapid-start Fairview II fluorescent fixture with a Bonus-Line ballast is listed by UL for direct mounting to any ceiling. This approval means that the Fairview II need no longer be spaced 1$\frac{1}{2}$ in. away from low-density ceilings. It is equipped with an internal non-resetting thermal-protected ballast. Fixture is available in 4- and 8-ft sizes for 120-volt rapid-start.

Day-Brite Lighting, Inc., 6260 N. Broadway, St. Louis 15, Mo.



Heating Units (7)

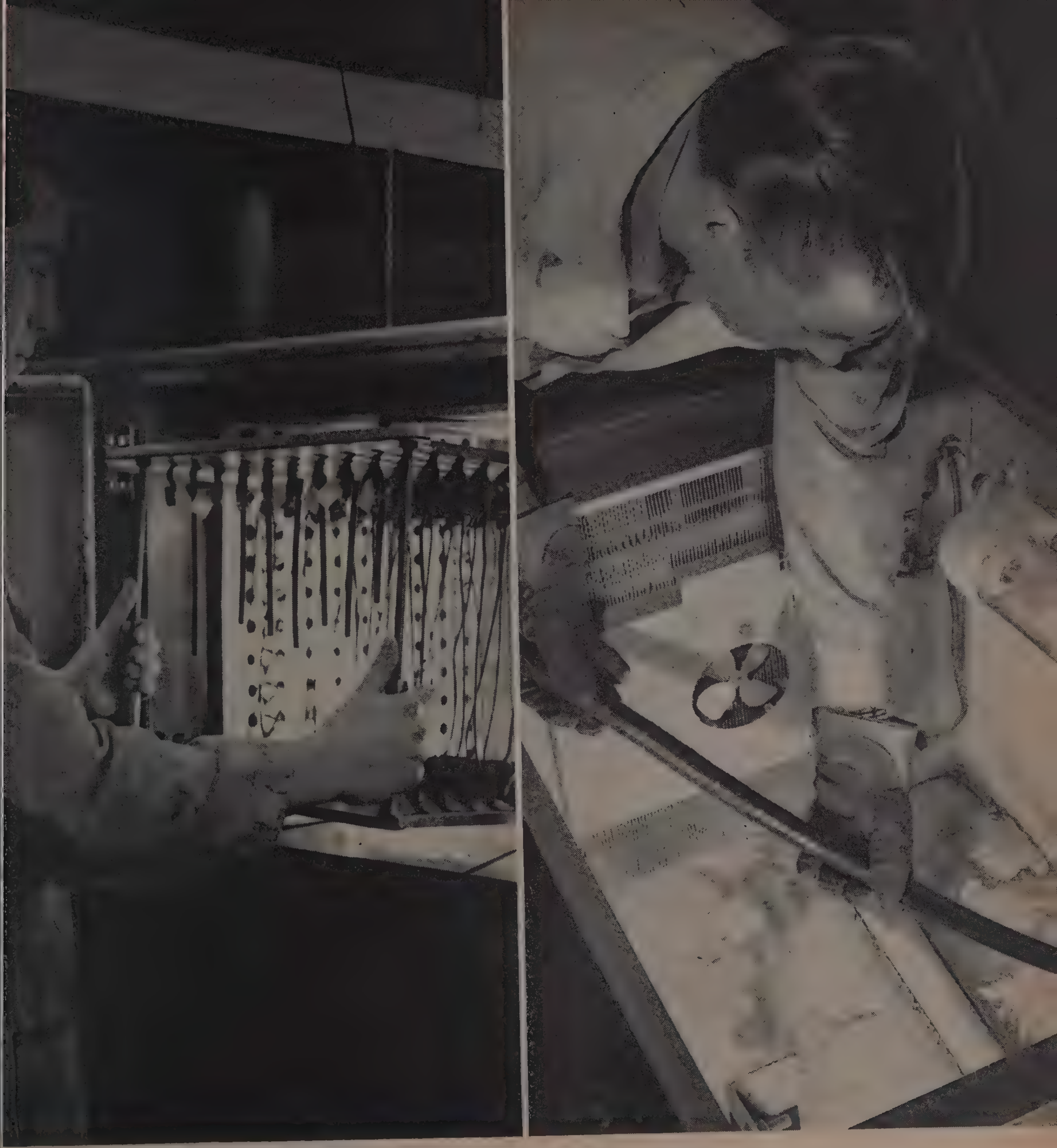
The "Custom" line is a new concept in electric baseboard heating units. Available in lengths from 2 to 8 ft, units are offered in wattages from 500 to 2000, progressively, in four standard lengths. Units are prewired and feature "flipover design" so that either end can face left or right. A junction box is the only accessory needed with this series. Junction box also serves as a fixture for a thermostat or outlet.

Arvin Industries, Inc., Columbus, Ind.

Exit Lighting (8)

A new exit light, called "Lumescent," has been introduced. A feature is its polyester-encapsulated cold light source provided by continuous discharge, miniature glow lamps. Units are of ultra-shallow design. Single face units are $\frac{13}{16}$-in. thick, double face lights are 1$\frac{7}{8}$ in. Frames and housing are of die-cast aluminum. Red lettering is standard for exit signs which have a metal stencil face. Units yield a soft diffused light with illumination equal to 15 watts fluorescent or 50 watts incandescent. Standard units operate on 105-125-volt supply.

Prescolite Manufacturing Corp., 1251 Doolittle Drive, San Leandro, Calif.



Hot and cold cable torture chambers...

mean better cable for you. Our aim at Circle is not just to meet specifications, but to see how far we can exceed them. This is the job of our cable testing laboratory.

High temperature aging ... sub-zero freezing ... ozone ... long-time water immersion ... and many other tests are performed continuously to assure maximum cable reliability. Add to this Circle's unmatched manufacturing experience and reputation for fast service and you'll see why Circle is the choice of so many cable users. For better cable at no extra cost specify Circle cable on your next job.

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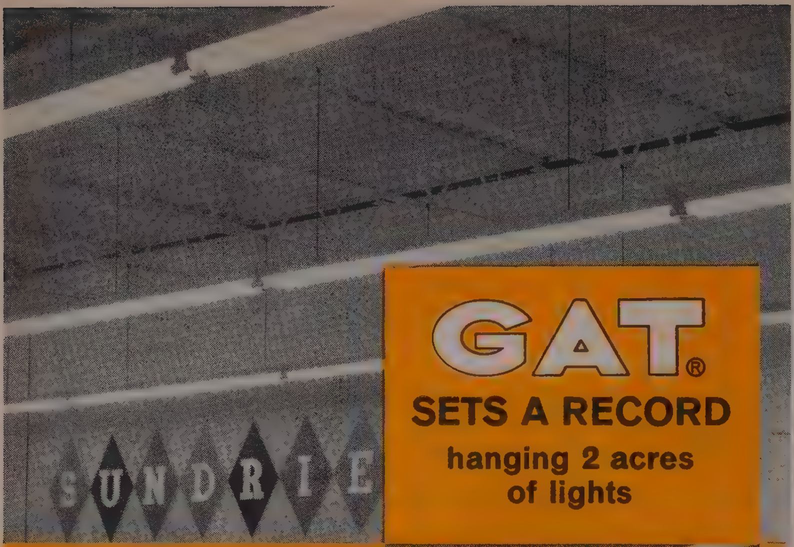

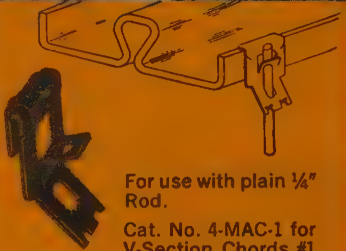

GAT®

SETS A RECORD

hanging 2 acres of lights

George Shafer, Gen. Supt.,
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Cleveland, Ohio says:

"This GAT job gave us a neat, simple, good looking, safe installation. GAT Macomber Joist Clips put wheels under this job, since all the hangers were pre-assembled on the ground; resulting in a much faster installation which was easier on the men and resulted in a lower in place cost over any other method."

For use with plain ¼" Rod.

Cat. No. 4-MAC-1 for V-Section Chords #1 through 8# and #10 and #11. Flanges 1/16 thru 5/32.

Cat. No. 4-MAC-2 for V-Section Chords #9 and #12 through #19. Flanges 5/32" thru ¼".

Recommended static load limit 200# with 4 to 1 factor of safety.

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CITY______ ZONE____ STATE______

Limit Stop (9)

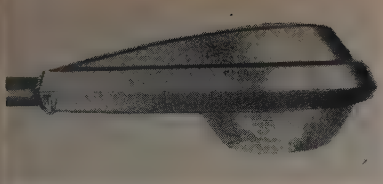
New P375 crane safety limit stop eliminates the need for duplex switches for applications over 200 hp. The device is especially designed for safe operation of large frame 618-622 mill motors. Heavy fabricated steel construction affords protection against shock and stress of crane duty. Used to prevent overtravel of the crane hook when hoisting, the P375 limit stop is provided with sealed and prelubricated bearings. Its weather-tight enclosure makes it suitable for outside use.

Cutler-Hammer, 315 North 12th St., Milwaukee 1, Wis.

Circuit Breaker (10)

A new 2-pole, 120/240 volts ac breaker for 225-amp service has been added to this line of molded-case breakers. The breaker is 3 in. wide, 7 in. high and 3⅜ in. deep overall. The EQ-225 breakers are designed for use as main breakers in load centers, in panelboards, or for individual mounting in commercial applications. They are ideal for single-phase, 3-wire applications in which interrupting requirements do not exceed 10,000 rms amps. Breakers are listed by UL in ratings from 125 through 225 amps. A quick-make, quick-break, trip-free operating mechanism is a basic design feature. Mechanism also provides for common-trip operation so that an overload or a fault in either pole automatically opens both poles of the breaker. The EQ-225 breaker has pressure type connectors which will accommodate copper or aluminum conductors with a wire range of No. 4 to 300 MCM cable.

I-T-E Circuit Breaker Co., 1900 Hamilton St., Philadelphia 30, Pa.



Luminaires **(11)**

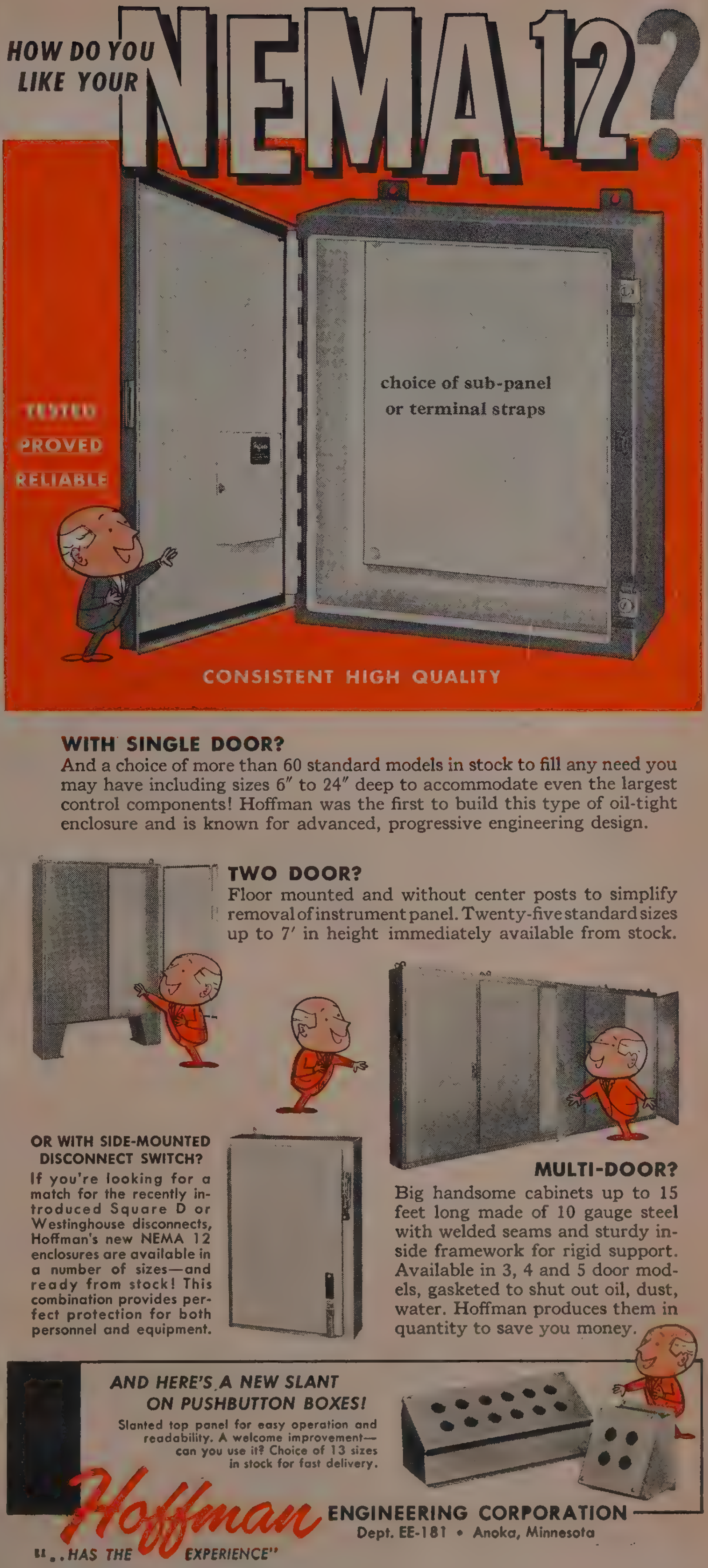
New internally ballasted mercury luminaires, designated Unistyle, are designed for high-level lighting of streets, highways and parking areas, operate horizontal clear- or color-improved lamps rated 100, 175 and 250 watts. Borosilicate refractors provide uniform light distribution in IES Type II, Type III, or Type II 4-way light patterns. These luminaires can be furnished with or without photoelectric control receptacles and are available with constant wattage or reactor ballasts for operation on 120/240-, 277- or 240/480-volt systems. Features are interchangeable heat-resistant glassware; standard reflector for all light distribution patterns; and quick-release latches on both refractor and reflector. Adjustable slip fitter compensates for pole rake and can be mounted on either 1¼- or 2-in. brackets.

Line Material Industries, McGraw-Edison Co., Milwaukee 1, Wis.

Heaters **(12)**

A new line of infrared heaters can be permanently installed on walls or ceiling. They are designed for homes as well as commercial buildings and facilities. With a fused quartz heating element, the heaters have semi-parabolic back reflectors plus two end reflectors to direct heat over a wide area. Installed directly to an existing outlet box, the heaters are available with either a ceiling only mounting or a ceiling and wall mounting. Listed by UL, units are thermal shock resistant. Units range from 500 to 1450 watts in 110/120 volts and from 750 to 2000 watts in 220/240-volt models.

Meier Division, Lau Blower Co., 3525 E. Washington St., Indianapolis 7, Ind.



HOW DO YOU LIKE YOUR NEMA 12?

WITH SINGLE DOOR?
And a choice of more than 60 standard models in stock to fill any need you may have including sizes 6″ to 24″ deep to accommodate even the largest control components! Hoffman was the first to build this type of oil-tight enclosure and is known for advanced, progressive engineering design.

TWO DOOR?
Floor mounted and without center posts to simplify removal of instrument panel. Twenty-five standard sizes up to 7′ in height immediately available from stock.

OR WITH SIDE-MOUNTED DISCONNECT SWITCH?
If you're looking for a match for the recently introduced Square D or Westinghouse disconnects, Hoffman's new NEMA 12 enclosures are available in a number of sizes—and ready from stock! This combination provides perfect protection for both personnel and equipment.

MULTI-DOOR?
Big handsome cabinets up to 15 feet long made of 10 gauge steel with welded seams and sturdy inside framework for rigid support. Available in 3, 4 and 5 door models, gasketed to shut out oil, dust, water. Hoffman produces them in quantity to save you money.

AND HERE'S A NEW SLANT ON PUSHBUTTON BOXES!
Slanted top panel for easy operation and readability. A welcome improvement—can you use it? Choice of 13 sizes in stock for fast delivery.

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HOW TO PROTECT SEMICONDUCTOR RECTIFIERS FROM DESTRUCTION

ANOTHER SHAWMUT "FIRST"

Faults in 65/130/250/600 volt circuits in silicon or germanium (semiconductor) rectifiers can develop current that will destroy them in less than a single cycle. Conventional breakers and fuses are too slow to protect against such destruction. This is why Shawmut, in conjunction with semiconductor rectifier designers, long ago developed the Form 101 *Amp-trap* to specifically solve this problem.

FORM 101 AMP-TRAP

Interrupting tests in all power ranges show that Form 101 *Amp-trap* becomes current limiting at about 4 times its normal current rating. This means that Form 101 prevents peak current build-up long before it can become destructive. At the same time it acts slowly enough so that there are no resultant destructive voltage transients.

POSITIVE PROTECTION

The Form 101 *Amp-trap* is available in ratings ranging from 1 to 10,000 Amperes. The sooner you apply it to your power circuits, the sooner you'll get the kind of "solid" protection your semiconductor rectifiers deserve. Send for Power Bulletin 101. Do it now.

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AMP-TRAPS — *"Awake At The Switch"*

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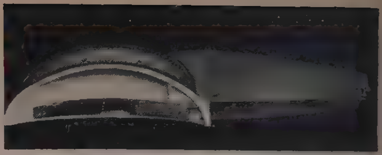


Luminaire (13)

A new horizontal crescent luminaire has been announced for rural and residential lighting. The body is cast aluminum, while the one-piece reflectors may be had in either porcelain enamel with stainless steel Edgeflectors, or heavy aluminum. The mogul socket takes 100- or 175-watt mercury vapor lamps. Provision is made for photo-electric control if desired. Ballasts and components are pre-wired to a terminal block. Unit accepts standard 1½-in. pipe arm.

Wheeler Reflector Co., Hanson, Mass.

Fire Alarm System (14)

A fire alarm system developed to serve as a fire detector in homes, farm buildings and business establishments has been introduced. Called the "Fire Watch Zoned Alarm Systems," it consists of a centrally located alarm panel connected to sensitive ceiling thermo detectors that are set to actuate when temperatures reach 135°F. The placing of detectors in any room or given area permits instant detection of a blaze and identifies its location on a central panel. Included also is a pushbutton system to test proper functioning. A 6- or 12-volt dry-battery-operated cut-out relay operates an outdoor bell or can be wired to shut off exhaust fans.

Slater Electric Inc., Glen Cove, L. I.

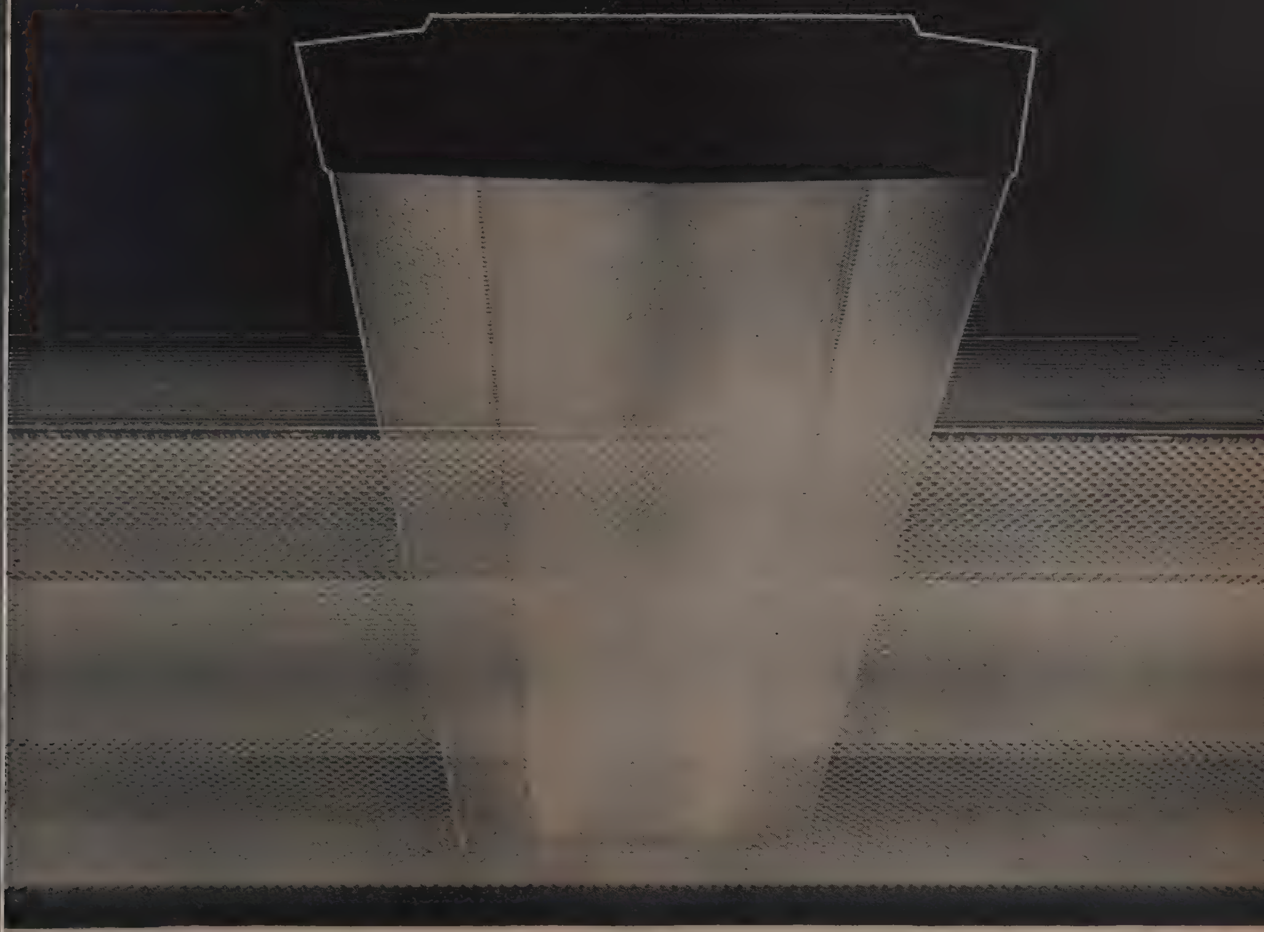
Grounding Devices (15)

New 15-amp, 277-volt grounding devices have been designed to meet the expanded use of 277-volt lighting in office buildings, industrial plants, large department stores, school, etc. The line includes grounding devices for both non-interlocking and interlocking type installations. The 3-wire Circlok line has been expanded to include the new 277-volt devices, including both grounding receptacles and armored male caps.

Circle F Manufacturing Co., Trenton, N. J.

[*Continued on page* 294]

LPI CRITERION



New LPI Criterion meets I.E.S. visual comfort recommendations employing unique new prismatic lens design

Now U.L. listed for direct surface mounting on combustible, low-density cellulose fiberboard ceilings

Here's an attractive, completely luminous luminaire series by LPI that offers a choice of lighting environment most suitable to the application.

LPI's Criterion I luminaire is engineered to provide optimum visual comfort where a high degree of brightness control is desired. This series alleviates direct glare in compliance with recommendations of the Illuminating Engineering Society. Its precisely controlled brightness complies with the I.E.S. "scissors curve" recommendations for visual comfort and permits arrangement of the luminaire either crosswise or lengthwise in a room regardless of the viewing angle.

Where the application calls for higher illumination levels than provided by the Criterion I, LPI's Criterion II fills the requirements. It offers excellent brightness control, but it is not designed to comply with the "scissors curve." Both luminaire models utilize lamps up to 3100 lumens and are available in two-lamp and four-lamp-tandem models.

For complete information on these attractive, modern luminaires write for LPI's Criterion bulletin.

Lighting Products Inc., Highland Park, Illinois

LPI FLUORESCENT LIGHTING

LPI-1-201A

NEW

PUMP PLIER

Here is a tool that should be in every lineman's and electrician's kit . . . the new Klein Pump Plier. Made in three sizes, 10 in., 12 in., and 16 in. It is adjustable . . . each size is suitable for many applications.

The jaws are locked into place for the desired sized opening by engaging a tongue in the proper groove. Jaws cannot slip even under heavy pressure. 10 in. and 12 in. available with or without yellow plastic handles. 16 in. supplied with yellow plastic handles.

Write for Bulletin 1261

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Reader's Quiz

QUESTIONS from readers on problems of industrial equipment, installation, maintenance and repairs. Answered by electrical maintenance engineers and industrial electrical contractors out of their experience. For every question and every answer published we pay $5.00

High-Voltage Cable

QUESTION X40 — I have come across varied opinions about the use of high-voltage shielded cables and the method of grounding. I would appreciate some expert advice.

This type of cable requires carefully made stress cones at each termination and at each splice. Some people say that all stress cones must be grounded. Others insist that the shield of each cable run should be grounded at one point only, to prevent excessive stray currents to flow in the cable shield. In this case only the stress cone at the line side of the cable is grounded. The length of the cable runs varies from short pieces to several thousand feet, with splices in many manholes. A third opinion is that it is better to use unshielded cable.

In the office there is usually very little or no information available about soil conditions with regards to stray currents, at job sites far away.—J.A.

ANSWER TO X40—The use of high-voltage cable requires the installation of stress cones at all splices for safety. All splices are a potential hazard to personnel, because they are usually made up in the field; and if not done right and under ideal conditions they may not be as good electrically as the rest of the unspliced cable.

An ungrounded splice wrapping may develop a tendency to go to ground. And anyone coming into contact with the cable at the splice will supply the ground path and could be electrocuted. It would be much better to have the splice shielded with a tinned all-copper mesh tape and grounded, so that any tendency to go to ground will cause the splice to blow up and be taken out of service by the automatic protective devices of the power system.

Several wire and cable manufacturers have excellent pamphlets that show the proper splicing methods for various high-voltage cables.—H.E.H.

Editor's Note:—Specific NEC rules, which pertain to the subject at hand, are Section 710-5, Table 710-5 and Section 710-6. These code rules state the conditions under which rubber-insulated cables used on systems over 600 volts should be provided with a metallic shield and how such shields should be grounded. However, several new developments in the insulation field have made it possible to use non-shielded cables in applications previously recommended for shielded cables only. As a result, it is advisable to discuss any proposed high-voltage cable installation with an application engineer of a wire and cable manufacturer, specializing in this field.—J.H.W.

Cool-White Fluorescent Tubes

QUESTION Y40—In a supermarket there is a row of 8-ft 2-lamp open fixtures with cool-white tubes. Some are 6 ft above an open meat display case. These were replaced with a pink lamp as the meat people claim cool-white or standard-white lamps "bleach" the meat.

1. *Is this true or is it for color effect to fool the shopper (one color in our store, another in your kitchen)?*
2. *If the whites do bleach the meat through the plastic wrapper, do the pinks lower lumens or have different wave lengths?—E.R.*

ANSWER TO Y40 — Cool-white lamps produce light with a dominant band in the blue region in contrast with the tungsten lamp which is rich in the red and orange region. The cool-white lamp is extensively used because of its higher lumen efficiency and a crisp psychological effect. The pink lamp has a phosphor formula which provides for more light in the red region, however, the lumen efficiency drops off. The color reflected from the meat depends on the color quality of the light source. The shopper has associated a fresh red color as an indication of good meat; the pink lamp merely creates the color quality the shopper is accustomed to; the light does not bleach the meat. Color is an important factor in lighting design. Imagine the effect if the light source was selected on the basis of lumen efficiency alone and mercury-vapor lamps were used.—A.W.C.

ANSWER TO Y40—The phosphor of the fluorescent lamp emits light in the visible spectrum mainly. This will not affect the color pigments in the meat. Dependent on the spectral distribution of the emitted light, however, the colors will look different from daylight. Deluxe coolwhite is recommended by the manufacturer, not to "fool" the shopper but to give a color rendition as close to daylight as possible. As to your second question: the pinks have different wave lengths insofar as a greater portion of the total visible spectrum is in a particular region. Lumen output, however, is the integrated output for all the visible light.—K.H.

Can You Answer These QUESTIONS?

QUESTION G41—We have recently encountered a rather interesting problem in the design of a power distribution system. We submitted to a client the design of a 3-phase, 4-wire distribution system with the neutral grounded at the transformer, but the neutral was not grounded at the individual power and lighting panels. The entire plant structural steel was bonded and adequately grounded.

However, they insisted that the neutral be grounded at every power and lighting panel.

Will someone please explain the advantages or disadvantages of the method required by our client. Further, what is the current trend in this area?—J.A.M.

QUESTION H41—In our plant, we have small power packs which generate about 8000-volts direct current for static precipitators in our air conditioning units. The tubes and other electronic components are mounted on insulating board, which lately has become conductive. Discharge between the high-voltage tube sockets and other devices and the grounded metal case is taking place and the precipitator grid does not receive the full voltage.

Is there any way to treat the insulating board to establish the original insulating value?—E.C.T.

QUESTION J41—What is a Faraday shield and how is it used?—J.B.K.

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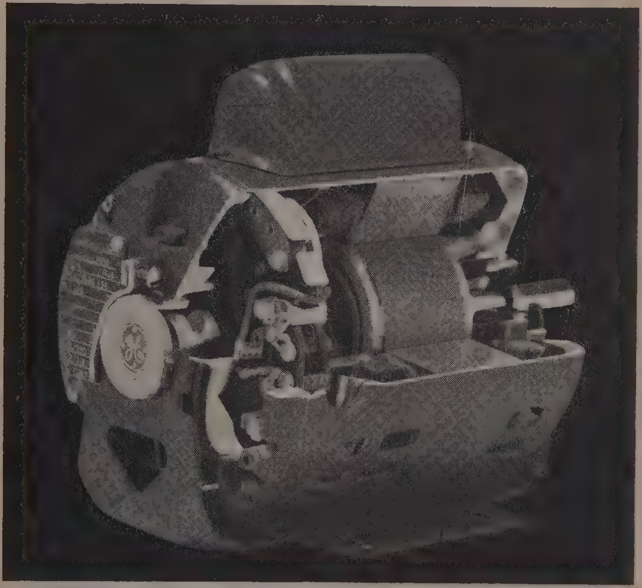

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General Electric offers you over 900 standard NEMA 48- and 56-frame Form G models—the most complete line available. They come in nearly every rating, enclosure and mounting used in domestic, commercial or industrial applications.

And, when you choose from this motor line you get the added benefit of field-proved performance. Over *22 million* Form G motors are providing dependable power in thousands of applications.

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615-04

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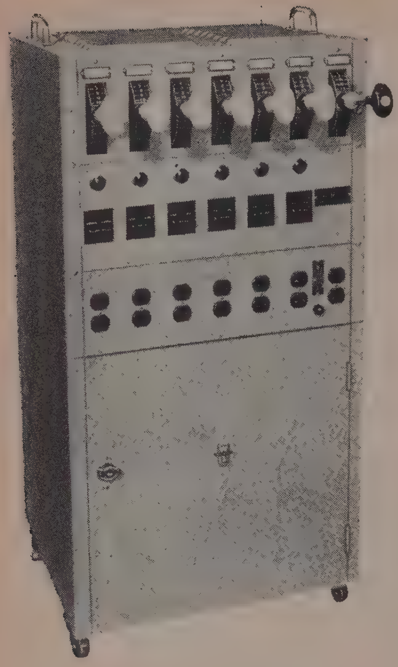

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Questions on The Code

Answered by:

R. L. LLOYD, *Electrical Safety Engineer, National Bureau of Standards, Washington, D. C.*
B. Z. SEGALL, *Consulting Electrical Engineer, New Orleans, La.*
R. E. WARD, *Chief Electrical Inspector, Insurance Department, State of Tennessee, Nashville, Tenn.*

READERS are invited to submit questions regarding the National Electrical Code and its practical application to this Department. Questions are answered by the consulting editor whose initials appear at the end of each item. The views and opinions expressed are, in each instance, those of the individual consultant replying and are not necessarily those of his employers, of this publication or of a Code-making committee or panel on which he may serve in an official capacity.

Wiring Gas Pumps

Q. *In the wiring for a gasoline pump that will serve only company equipment, such pump would be located within the fenced-in night parking area on company property immediately adjacent to a company warehouse of masonry construction. There are no openings in the building wall within 25 ft of the proposed gasoline pump location. The circuit for the pump wiring is to be run from the service equipment located inside the warehouse building to a point inside the building wall, then through the building wall to an outside weatherproof switch or breaker located and secured to the masonry wall near the pump location. Such switch or breaker would be located 7 ft from ground level, and such that can be locked in the open position as it will be necessary for truck drivers to obtain gasoline that will not have access to the main service equipment. The method of wiring will be rigid metal conduit with a seal below the weatherproof switch or breaker in the raceway going to the pump. There will be another seal at the pump according to the requirements of the code. Conductors will be THW from service equipment to outside switch or breaker. Conductors from switch or breaker to pump connection will be approved for use in Class I. Division 1 location, as is outlined in Section 501-13.*

Due to the fact that the switch or breaker on wall of building is less than 20 ft from the gasoline pump, does the code require the switch or breaker to be explosion-proof, and the conductors entering such device to be approved for Class I, Division 1 location?—R.S.M.

A. From the statement given in your letter, my answer is no to both parts of your question. According to your statement there is no opening in the building wall for a distance of 25 ft. Therefore, the building is suitably cut off from the hazardous area. Your switch or breaker is located at a 7-ft level, which will be out of the hazardous area. Seals and approved conductors are provided in the hazardous area. Therefore, I will say your installation when completed according to Article 514 should be acceptable. —R.E.W.

Grounding With NM Cables

Q. *In the wiring for a receptacle that is to supply an appliance having 115/230-volt requirements, with a requirement for grounding, the method of wiring is non-metallic sheathed cable, requiring four conductors—two ungrounded conductors, a neutral conductor and a grounding conductor.*

Can two runs of 2-wire cable be installed to meet code requirements?—W.B.R.

A. My interpretation would be yes when the requirements as outlined in Section 200-7, Exception No. 1, are followed, including the explanation given in the fine print note which is as follows:

"Identified Conductor in Grounded Circuits Only. Conductors having white or natural gray covering shall not be used other than as conductors for which identification is required by Section 200-2, except under the following conditions, and then only where they are, in other respects, suitable

For use as ungrounded conductors in the circuit:

"Exception No. 1. Identified conductors, rendered permanently unidentified by painting or other effective means at each outlet where the conductors are visible and accessible, may be used as unidentified conductors."

(*Fineprint note*) "The foregoing permits the use of 2-wire cable having one black and one white conductor on 2-wire circuits tapped from the outside legs of a 3-wire system or any two conductors of a multi-wire system where the identified conductor of the 2-wire cable is rendered permanently unidentified at terminals."

In the fineprint note no mention is made with reference to identification of the grounding conductor; however, mention is made of the grounding conductor under Section 210-5, subject being "Color Code," and the following is the last paragraph of the above-mentioned section. "Any conductor intended solely for grounding purposes shall be identified by a green color unless it be bare. Conductors having a green covering shall not be used for other than grounding purposes."—R.E.W.

Double-Pole Switches for Two Circuits

Q. *In a public building, inside restrooms are to be equipped with a small ventilating fan and one incandescent light in each restroom, the light outlet to be a standard base lampholder. Specifications for the installation of the fans and lights are as follows. There will be a total of four restrooms with the four lights on a 20-amp branch circuit and the four fans on another 20-amp branch circuit, with the light and fan for each restroom controlled by a double-pole toggle switch of sufficient size to carry the load and located inside the restroom at the door. This will assure the operation of the fan when the light is turned on and off.*

Is there a code violation in the wiring of the toggle switch when the circuit conductors to such switch could be of opposite polarity with 230 volts between circuit conductors in the switchbox or enclosure?—W.B.R.

A. Your question is one that I am sure there could be a difference of opinion. My answer is that there is no code violation, and

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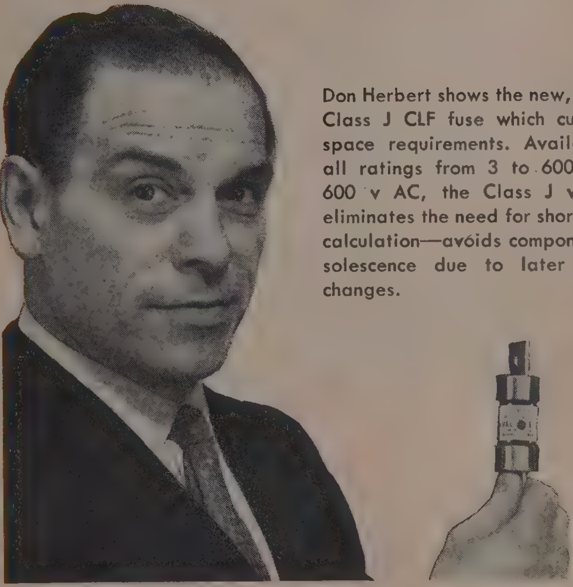
Forget Short-circuit Worries, Let CLF* Fuses Protect Your Electrical Power System



Don Herbert shows the new, smaller Class J CLF fuse which cuts your space requirements. Available in all ratings from 3 to 600 amps, 600 v AC, the Class J virtually eliminates the need for short-circuit calculation—avoids component obsolescence due to later system changes.

You can forget short-circuit worries with the 200,000 rms symmetrical ampere interrupting tested rating of CLF fuses. As your electrical distribution system changes and expands, CLF fuses continue to give you reliable protection. You retain your system's flexibility. You have current limiting protection instead of damaged equipment. CLF fuses do not age as conventional fuses do. This ends nuisance blowing. Contact your local G-E distributor for CLF fuses, the complete family of protection: ratings from 3 to 4,000 amps. And, for more information, circle number 7 on the General Electric postcard on following page. 615-07

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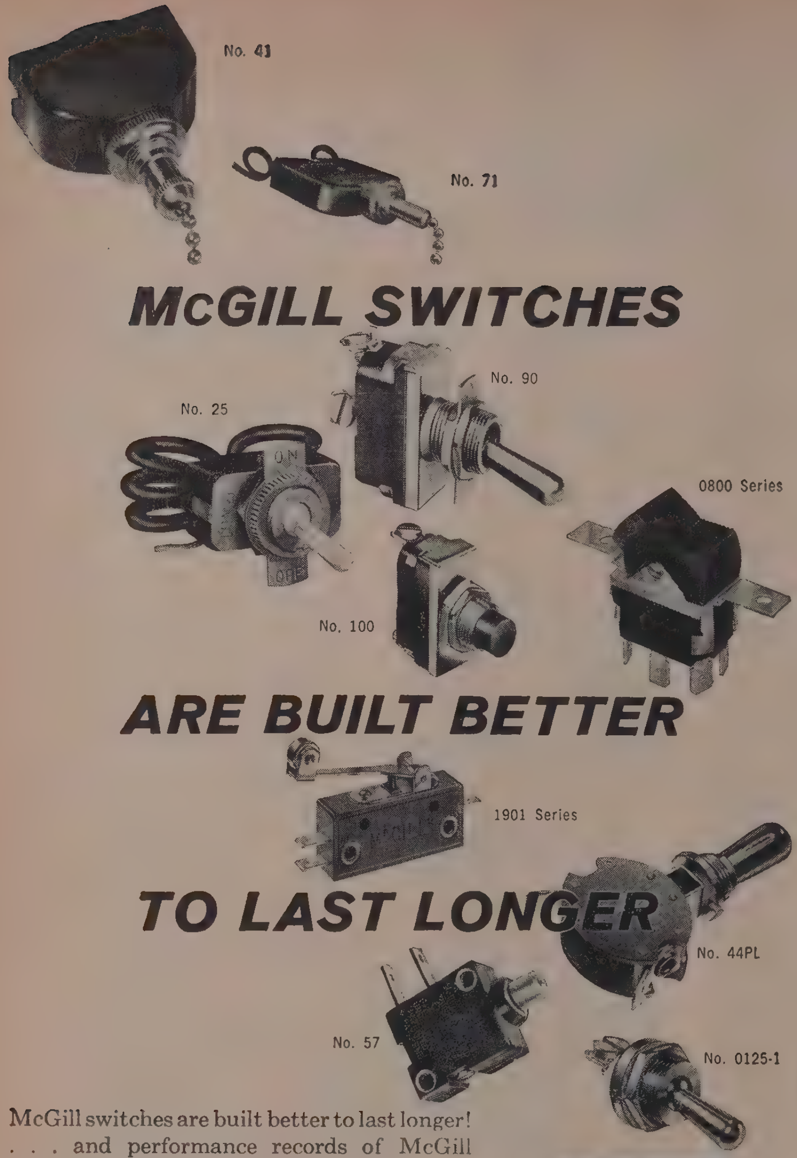

McGill switches are built better to last longer! . . . and performance records of McGill switches prove that they *do* last longer. Thousands of No. 41 LEVOLIER switches, for canopy controlled lighting, are still in use today as testimonial of the McGill reputation for quality. The No. 41 switch is unconditionally guaranteed in lighting circuit use. The McGill line today provides toggle, momentary contact, rocker, push-button, canopy and many special switches to meet the needs of modern circuit control. Every McGill switch is built to the same high standards of quality . . . the kind of quality that pays for itself many times in savings on maintenance and "down time." Demand the best. Demand McGill switches.

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I base my statement on the following. Paragraph 210-6(a) states i part "The voltage to ground o branch circuits supplying lampholders, fixtures, or standard receptacles of 15-amp or less rating sha not exceed 150 volts, except as follows: . . ." Your voltage to groun does not exceed the 150 volts supplying either lights or fans, although voltage between conductor in the switch enclosure could excee the 150-volt limit. However, n mention is made of switch enclosures.

Paragraph 210-6(b) concern voltage between conductors i dwelling occupancies, and no mention is made in the code of a condition such as you describe. I other words, the switch enclosure i not mentioned, and this section pertains only to dwelling occupancie if such were mentioned.

Therefore, in my opinion, Sectio 210-6 does not prohibit an installation such as you describe. Sna switches of the ac-dc types usuall carry both 125-volt and 250-vol ratings, and in such instances, th amperage rating at 250 volts is one half of the rating at 125 volts. Besides this, the switch rating mus be large enough to handle twice th current rating of any motor (o other inductive load) it controls.

On the other hand, ac general use snap switches with a dual rating of 120/277 volts could be use at the single full-load ampere rating of the switch for lighting loads, an 80% of the rating for motors no exceeding 2 hp.—R.E.W.

Motor Controllers and Disconnects

Q. *Article 430 of the code pertains to motors and moto controllers. Part G of this articl is "Motor Controllers" and Part F is "Disconnecting Means."*

Would an installation wired i accordance with Paragraphs 430-8 (a) or (b) meet code requirement as the disconnecting means for motor of over 2 hp and not over 5 hp?—M.K.D.

A. In Section 430-102 it i stated that "the disconnecting means shall be located in sigh from the controller location or b arranged to be locked in the ope position." And Section 430-10 states that "the disconnecting means shall disconnect both th motor and the controller from al ungrounded supply conductors. Th disconnecting means may be in the same enclosure with the controller." Under Section 430-86, which pertains to motor controllers, it is stated: "Where a motor and the driven machinery are not in sight from the controller location, the controller shall comply with one of the following conditions: (a) The controller or its disconnecting means is capable of being locked in the open position, unless special permission is given by the authority enforcing this code. (b) A manually operable switch, which will prevent the starting of the motor, is placed within sight from the motor location. This switch may be placed in the control circuit of the magnetic controller."

As to paragraph (a) of this section, my interpretation would be that the disconnecting means would be according to Part H of Article 430. In other words, the disconnecting means must be approved for the purpose. If the controller and its disconnecting means are at the same location, either the controller or the disconnecting means could be capable of being locked in the open position. If the disconnecting means is not located in sight from the controller, it would be necessary for the disconnecting means to be locked in the open position to satisfy Section 430-102. On the other hand, it should be noted that special permission could be given by the authority enforcing the code to waive this requirement. See Paragraph 430-86 (a).

Under Paragraph 430-86 (b) the manually operable switch inserted in the control circuit of the magnetic controller would not, in my opinion, satisfy code requirements for the disconnecting means. This switch would be an extra precaution for the protection of a person who would be working on the machinery. A control station with an approved disconnecting means would be required in addition to this switch. I have in mind motors that drive machinery in feed mills or like installations. In such cases, the disconnecting means and controllers are remotely located from the motors that operate machinery. When it is necessary that attendants work on such machinery, it is very important that such machinery cannot be operated.

To summarize your question, it is my opinion that a motor should have an approved disconnecting means according to Part H of Article 430. Such a disconnecting means should be located in sight from the controller location or be arranged

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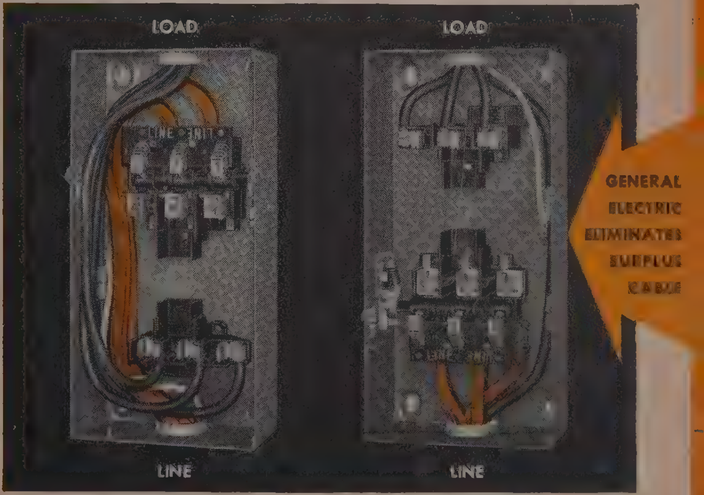
G-E Reversible-wiring Safety Switches Slash Cable Costs and Installation Time



OLD WAY NEW WAY

Save up to $30 on cable cost with new General Electric reversible-wiring safety switches. Based on typical conductor costs for a 3-pole 600 amp/600 volt G-E switch installation using 350MCM conductor, you save $30.60 on cable cost alone—36½ feet of heavy cable, *plus the time and labor to bend and install it.* On some installations, Codes prevent looping inside the switch, which means even more expensive gutter runs. G.E. eliminates looped cable and the danger of wire abrasion inside the box. Switches are available with line lugs factory installed at bottom, or for field installation. The normal ON-OFF indication remains unchanged.

Ask your distributor about G-E reversible-wiring safety switches during the Banner Year of Value, and circle number 2 on the G-E postcard on a following page.

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¾" Conduit or Pipe	4⅛"	EMT 5"
1" Conduit or Pipe	5¼"	EMT 6"
	No. 5200	No. 5400
1¼" Conduit or Pipe	6⅞"	EMT 8"
1½" Conduit or Pipe	8¼"	EMT 10"

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to be locked in the open position. And when a motor and the driven machinery are not in sight from the controller location, the controller shall comply with either paragraphs (a) or (b) of Section 430-86, and this speaks only of the controller and does not take the place of an approved disconnecting means.—R.E.W.

Editor's Note—Since the "special permission" clause of Paragraph 430-86 (a) is mentioned in this discussion, it is significant to note that this clause may not appear in the 1962 Code edition. The informal report of CMP No. 11 indicated at the recent NFPA meeting in Detroit that the special permission mentioned in the code rule in question served no useful purpose and should be deleted. However, until the panel's recommendation is formally adopted and included in the 1962 Code, the authority enforcing the code is in the position to permit alternates to the requirements of present Paragraph 430-86 (a).—J.H.W.

Aluminum Conduit Service Masts

Q. *Can aluminum conduit be used for service-entrance masts?—R.B.J.*

A. Your question is one that is not directly answered by the NEC.

According to published information from the Rome Cable Division of Alcoa, Pittsburgh, Pa., a similar question has been asked and the following is their answer: "If you guy the aluminum or strap it to a pole (it should be satisfactory). Don't use it unsupported as you would a steel pipe, however, as it might bend under a very heavy load." It is also stated that "the comparable strength of mild steel used for conduit has about 45,000 p.s.i. ultimate strength, with about 20% elongation, compared to 22,000 p.s.i. and 20% for aluminum."

In the State of Tennessee we have printed state regulations relating to electrical installations. This regulation is based on the NEC, and items not covered in the regulation are the same as the current edition of the NEC. Under Services, Item 38 of the state regulations reads as follows concerning your question:

"Buildings of low-wall construction or buildings with excessive overhang may use the telescopetype service extending above the roof of such building to obtain proper clearances of conductors. Risers shall be rigid conduit of corrosion-resistant material, minimum size 2 in. extending a minimum of 3 ft above roof. (Due to local requirements in some areas, check above with local inspector or power distributor before installation is made.) (Where aluminum conduit is used, anchoring with brace will be required.)"—R.E.W.

Hospital Wiring Methods

Q. *In a small hospital or clinic of one story with adequate exit ways to ground level, the method of wiring that has been specified for corridors and patient rooms is non-metallic sheathed cable. Operating rooms, delivery rooms and anesthesia storage locations are specified as metallic raceways according to NFPA No. 56 and the National Electrical Code.*

Does the NEC prohibit the use of non-metallic sheathed cable in the areas specified when properly installed?—J.F.

A. No. It does not. There are certain locations such as you mention that the method of wiring specified is other than non-metallic sheathed cable. Before the installation is made a check should be made to determine whether or not such hospital or clinic is in a restricted fire zone, or if there is a local ordinance or local requirement prohibiting the use of the material specified.—R.E.W.

Multiple Fuses

Q. *I have an installation calling for a 1200-amp service switch with the switch specified having fuses of 600 amps in multiple. This being our first switch of such design to be specified, can such be approved as meeting code requirements?—S.R.*

A. Yes. Section 380-17 states: "Multiple Fuses. Switches rated above 600 amps may be arranged for fuses in multiple provided as few fuses as possible are used and the fuses are of the same type and rating and are so mounted as to eliminate a potential difference between the terminals of the fuses."—R.E.W.

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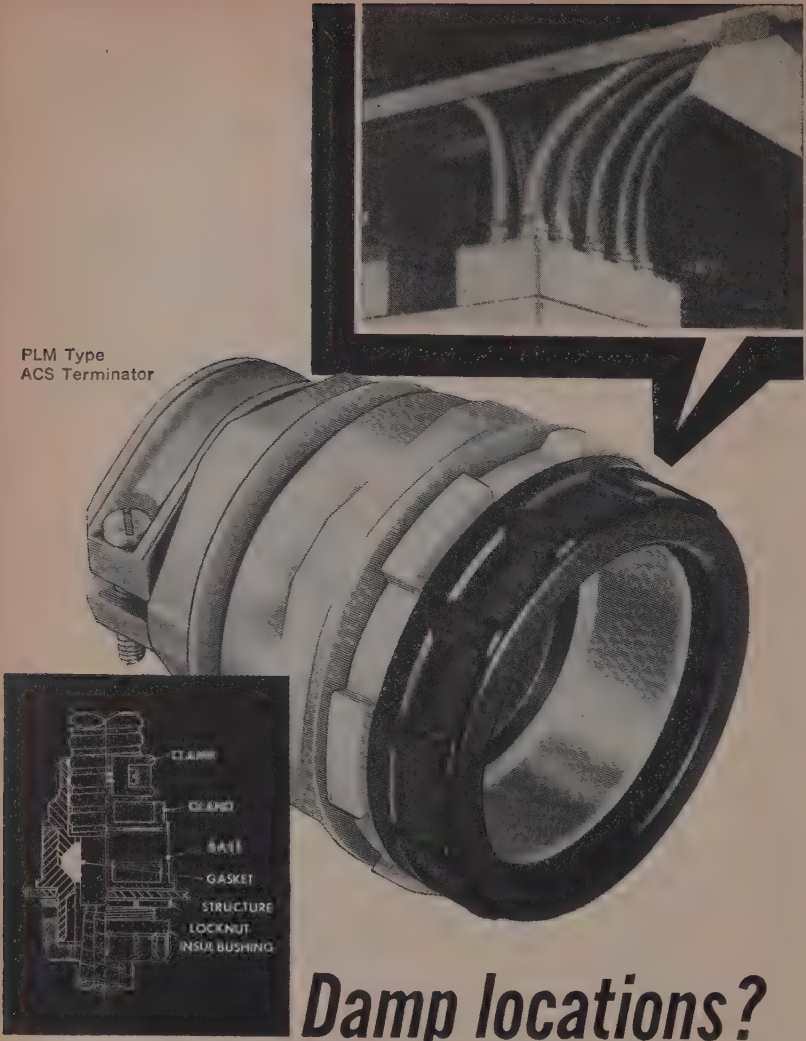

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Grounding Portable Equipment

Q. *Presently we are planning a change-over in our electrical equipment and improvement for safety, and are under the impression that our electrical circuit is the safest for our kind of application, but discussions with several engineers lead us to believe differently, yet with doubt. Therefore, it is hoped that you can assist in making a decision as to the method of electrical installation which would be best suited for the following situation:*

Method 1-A 45-kw, 208-volt portable generator, is feeding a rubber-tired cement vehicle, operating in a metallic pipe underground, through an 800-ft-long drop cord. This is a 3-phase, 4-wire system, with the fourth wire a dead-metal equipment ground leading back to the generator. Additional grounding is obtained by grounding the cement vehicle to the metallic pipe. The pipe, generator and white neutral are all grounded on a driven stake separately.

This system is now in question as to whether or not it is in the best of electrical engineering practices.

Method 2 would put all conditions the same as Method 1, with the exception there would be no ground wire or grounding of any kind installed or could be considered isolated.

Which system would be preferred for the situation we present?—J.J.P.

A. In answer to your question the following comments are made. As I understand your statement, the 45-kw portable generator is installed at some point outside of a large underground metallic pipe. This generator supplies a 3-phase motor-operated rubber-tired vehicle that is guided through the pipe by an operator. Method 1 is what you now have, and your question concerns whether or not to change from Method 1, which is a grounded system, to Method 2, which is an isolated system.

Section 445-8 of the code requires that "if a generator operates at a terminal voltage in excess of 150 volts to ground, the frame shall be grounded in the manner specified in Article 250. If the frame is not grounded, it shall be permanently and effectively insulated from the ground." It would seem to me that the latter part of this rule would be hard to accomplish; therefore, the grounding would be required.

The latter part of the definition of voltage to ground in Article 100 states "in ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit," and when the grounding is removed as is outlined in Method 2, the voltage would exceed the 150 volts mentioned. In addition to this observation one must consider the provisions of Paragraph 250-45(d), which in my opinion would require the grounding of the motor frame attached to the rubber-tired vehicle that is operated inside of the underground metallic pipe, and the grounding of this portable apparatus must be accomplished by the provisions of Section 250-59. To accomplish this and to provide a path of low impedance, I would strongly recommend the use of a 4-wire portable cord with one of the conductors used as a grounding conductor. Assuming that the generator is wye-connected, the neutral should be bonded to the generator frame and connected to a driven ground. In addition, the driven ground should be bonded to the underground metallic pipe with all metal parts and raceways bonded together.—R.E.W.

Appliance Branch Circuits

Q. *In a single family residence a disposal unit is installed at the kitchen sink. Such disposal unit is cord connected and supplied from a grounding-type receptacle on an individual 20-amp circuit.*

Can this circuit be counted as one of the circuits required under 220-3(b)?—A.B.G.

A. No. Paragraph 220-3(a) states: "For lighting, and for appliances, including motor-operated appliances, not specifically provided for in Paragraph 220-3-(b), branch circuits shall be provided for a computed load not less than that determined by Section 220-2."

Under Paragraph 220-3(b) it is stated: "For the small appliance load in kitchen, laundry, pantry, dining-room and breakfast-room of dwelling occupancies, two or more 20-amp branch circuits in addition to the branch circuits specified in Paragraph 220-3(a) shall be provided for all receptacle outlets (other than outlets for clocks) in these rooms, and such circuits shall have no other outlets."—R.E.W.

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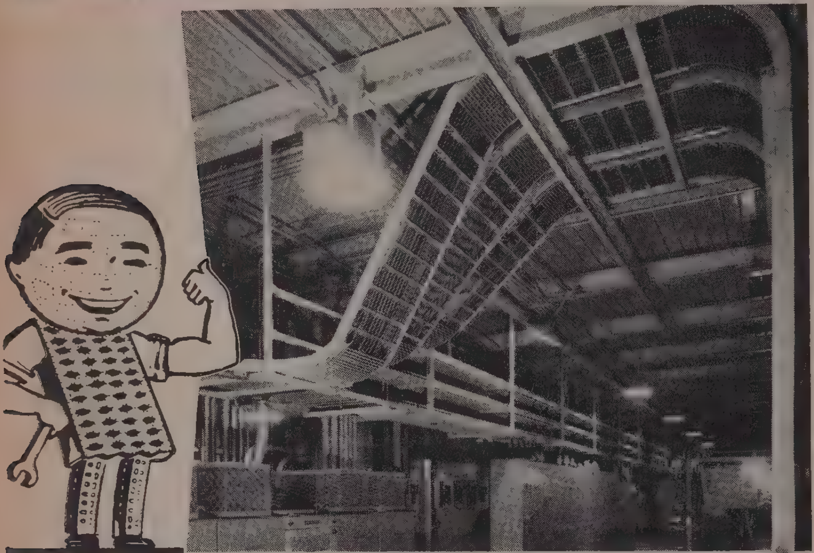

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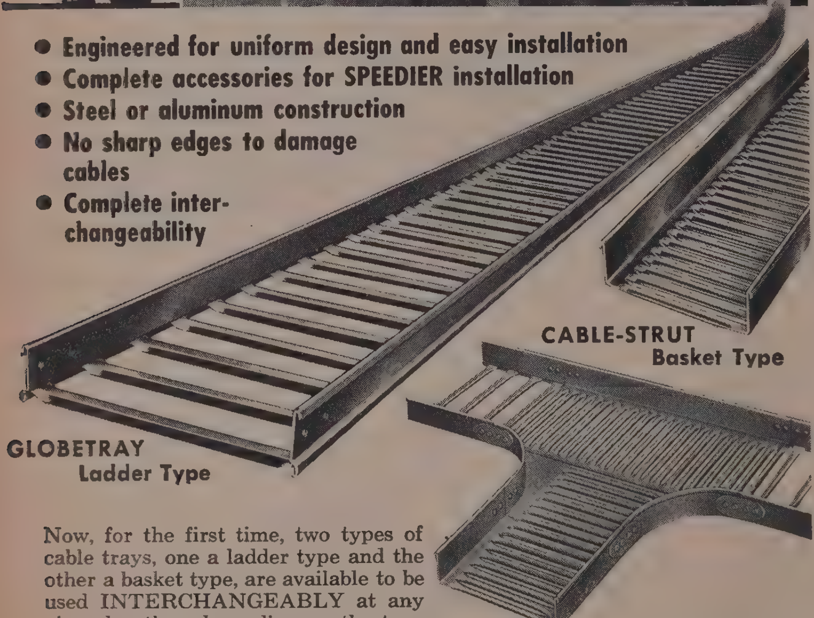

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Services for Mobile Homes

Q. *According to Publication No. 501-B of the National Fire Protection Association, Chapter 4, relating to electrical systems and equipment for mobile homes and travel trailers, a mobile home or travel trailer may have disconnecting means of not less than 50 amps where such mobile home is to be used the same as a one-family dwelling with sleeping, cooking and sanitary facilities. If the demand of such mobile home or trailer is in excess of 50 amps or if a separately metered appliance is installed, a second service disconnecting equipment shall be installed and supplied by a second supply cord.*

When a mobile home or trailer requires a service in excess of the two 50-amp disconnect means as mentioned above, what method of installing such disconnecting means shall be used?—C.K.

A. In Chapter 4 of the above-mentioned standard under general requirements it is stated: "All electrical equipment and materials shall be approved and installed in accordance with the requirements of the NEC except where specifically modified by this standard." I am sure there will be certain cases where mobile homes or trailers will be used for special purposes, such as coin-operated laundry establishments where washing and drying are done electrically, where the two 50-amp service disconnects will not be of adequate size for the connected load. Such installations will of necessity be treated on individual basis, and my opinion would be that the NEC should be followed in such installations, with the requirements of Chapter 4 of 501-B being adhered to as to the requirements that are different or in addition to the requirements of the NEC.

As an example, it is stated that the disconnecting means and branch-circuit protective equipment shall contain a solderless type of grounding connector or bar for the purpose of grounding. The neutral bar termination of the grounded circuit conductors shall be insulated. In other words, should an installation require a 200-amp service the above requirements for the grounding connector and the insulated neutral bar would be followed the same as in a 50-amp installation.

The State of Oregon has recently enacted requirements for electrical systems and equipment in trailers. Their requirements state "that trailers requiring over 100-amp supply shall be supplied overhead through a mast and four conductors, one of which shall be the grounding conductor." This is in line with the requirements of Section 501-B which requires a grounding conductor for each supply cord. Ordinarily, the supply cord will have two ungrounded conductors, an insulated neutral conductor and a grounding conductor. It is proposed that the electrical requirements for mobile homes and travel trailers be incorporated in the 1962 edition of the NEC.—R.E.W.

Grounding-Type Receptacles in Trailers

Q. In the National Fire Protection Association Publication No. 501*B, Standard for Fire Prevention and Fire Protection in Mobile Homes and Travel Trailers, published in May* 1961, *under Item* 462 *the following is recorded: "All convenience outlets shall be grounding type."*

In the making of the above requirement, was it the committee's opinion that the trend is for grounding-type receptacles to be installed in all occupancies?—H.M.B.

A. Yes. The writer is a member of the committee on Trailers and Trailer Courts, and it was the opinion of the committee that within a few years time grounding-type receptacles will be standard for all occupancies. This thinking is in line with recommendations that have been made for the 1962 NEC.

There are many valid reasons for the use of grounding-type receptacles, some of which I call to your attention as follows: The grounding-type receptacle will accommodate 2-wire attachment plugs that are standard today. Appliances and devices equipped with 3-wire cord and grounding-type attachment plugs cannot be used in standard receptacles without the use of an adapter. Therefore, by using the grounding-type receptacle, appliances, devices and lamps may be used with either type receptacle.

Under our present code, grounding-type receptacles are required under certain conditions while standard receptacles may be used in many places. When both types are used it simply means that the electrical contractor, the jobber,

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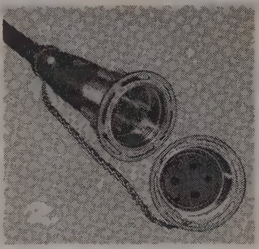

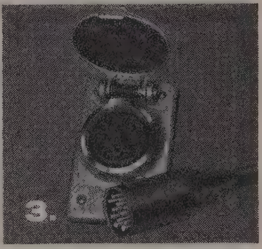

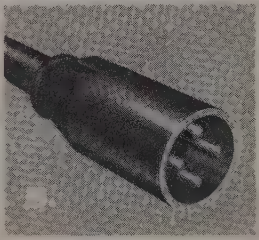

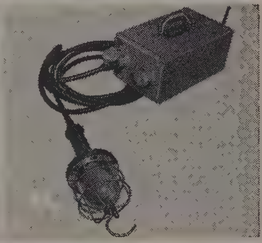

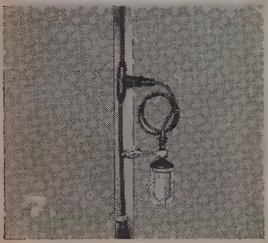

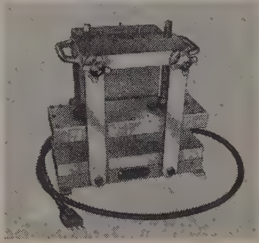

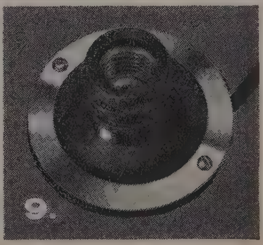

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the wholesaler and the manufacturer carries two items, but if only one was required, one item could be eliminated.

With the requirement of grounding-type receptacles it will become standard practice that a grounding conductor or an approved method of grounding be provided for practically all outlets. This will mean that on future additions or installations of new equipment that requires grounding, the provision for grounding will be available, which will certainly be an improvement over our present method where the special permission rule is used many times for the grounding of equipment, and in many instances grounding is not provided due to various reasons. On an original installation, grounding-type receptacles with an approved method for grounding can be installed throughout with little additional expense above our present standard, and I am sure that this cost can be lowered by standardization of wiring methods and materials.—R.E.W.

Grounding Surgical Fixtures

Q. *Recently I installed a large UL-listed hospital operating room light. The electrical inspector in making his inspection found that a part of this operating room light that was made of metal, and within reach of the floor, was not grounded, while the upper part of the fixture was grounded. It was found that ground continuity was not maintained due to an insulating bushing or bearing that was a part of the fixture. Before the installation could be approved it was necessary that a flexible grounding strap be connected between the grounded and ungrounded sections of this fixture.*

This being a listed fixture, could the inspector require the grounding of the ungrounded portion of the housing of the fixture?—S.L.C.

A. Yes. All parts of surgical fixtures should be grounded in accordance with Section 2483 of the NFPA Code for the use of flammable anesthetics (No. 56), which carries a cross reference to Section 501-16 of the NEC. 501-16(a), which applies to exposed metal parts in Class I, Divisions 1 and 2, states that "the exposed non-current-carrying metal parts of equipment such as the frames or metal

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xteriors of motors, fixed or portble lamps or appliances, lighting xtures, cabinets, cases, and conuit, shall be grounded as specified n Article 250 of this code." The bove statement in the NEC is pracically the same as 2483 mentioned bove. Therefore, the electrical inpector was within his rights in reuiring the grounding of the fixure. And as an assistance to UL e should report his findings to hem in addition to the manufacurer.—R.E.W.

witch Ratings

Q. *In the installation of service switches I have noticed that uany switches have a hp rating hile other switches of similar conruction and looks do not have such ating.*

Does the horsepower rating deote that this type switch is of igher quality than a switch withut such rating—W.M.S.

A. Service switches listed by UL that are marked with orsepower ratings are tested at ated voltage, and at six times mor full-load running current for ac atings and at four times motor ull-load running current for dc atings.

Disconnecting means for motors re covered in Part H of Article 430 f the NEC and this section of the ode states where horsepower rated vitches are to be used. In Part H, motor-circuit switch is mentioned, nd under the definition in Article 00 of the Code, "a motor circuit vitch is one rated in horsepower, pable of interrupting the maxium operating overload current of motor of the same horsepower ting as the switch at the rated ltage."

The definition of a general use vitch, which would not necessarily ave a horsepower rating, is "a vitch intended for use as a switch general distribution and branch rcuits. It is rated in amperes and capable of interrupting its rated rrent at its rated voltage."

In direct answer to your question, will state that a switch with a hp ting has met requirements that general-use switch is not required meet, and may or may not be of gher quality than a general-use vitch. One would have to know if e general-use switch had been sted as a hp rated switch and the sults of tests made before a defite answer could be given concerng your question.—R.E.W.

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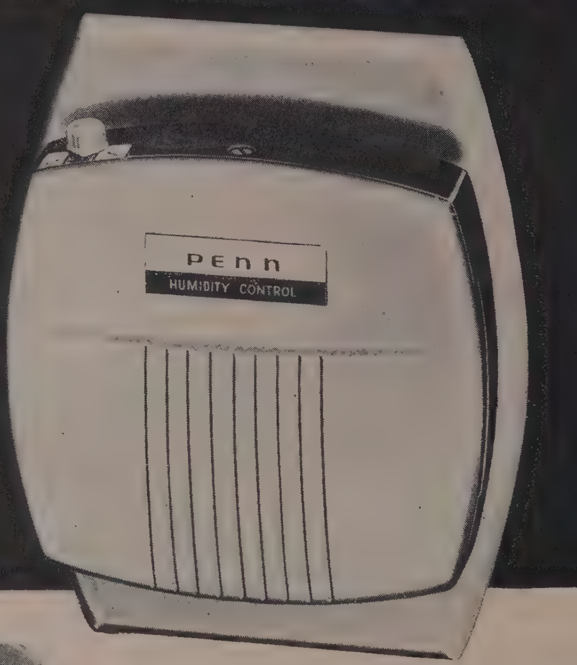

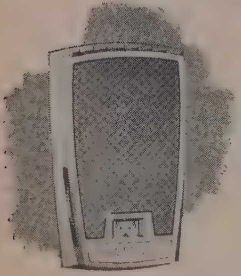

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area-lights have been added to this
line of luminaires for quartz-iodine
lamps. Three versions of the area-
light, which uses 500-watt T
quartz-iodine lamps, are offered
For pole-top mounting, Cat. No
6803-2NF with two luminaire units
mounted back-to-back, or Cat. No
6803-1NF with one functional and
one "dummy" luminaire uni
mounted back-to-back. The latter
arrangement is employed where i
is desired to illuminate only one
side of a boundary while at th
same time preserving uniformity o
appearance with other pole-top
area-lights. The third version i
Cat. No. 6808-1NF wall-mounted
area-light—a single luminaire uni
which mounts flush to a vertica
surface by means of four bolts
Bulletin 100-43-9 is available.

*Revere Electric Mfg. Co., 742
Lehigh Ave., Chicago 48, Ill.*

Circuit Breaker (17

The Series AM12 line of circui
breakers for electrical and elec
tronic equipment has been expande
by adding 4-, 5- and 6-pole model
Typical applications for the break
ers include single-unit overcurren
protection for the input and outpu
of 3-phase power supplies an
transformers. The 6-pole model ca
also be used to protect all phase
of a 6-phase rectifier. All of th
models can be furnished with a
auxiliary switch on each pole t
control up to 12 separate but r
lated circuits. The new multip
models are common-trip breaker
which will interrupt all circuits s
multaneously when there is an ove
load in any one pole. AM12 mode
can be supplied for dc or 60- c

400-cycle ac service with any continuous current rating from .020 to 50 amps. Standard maximum voltages are 50 volts dc; 250 volts 60-cycle ac; and 208 volts 400-cycle ac. Overall dimensions of the 6-pole model are 2.53 in. high by 4.59 in. wide by 2.63 in. deep.

Heinemann Electric Co., 234 Magnetic Drive, Trenton 2, N. J.

Heaters **(18)**

New line of heavy-duty electric fan-forced unit heaters for industrial, commercial and retail establishments. The capacities of this expanded line of unit Heetaires, Series 600, range from 2 kw to 30 kw with 208, 240, 277, 480 and 575 volts in single and 3-phase types, with either built-in or remote thermostat controls. Units are designed to be either suspended from ceiling, or wall, or used as portables. The motors, designed for industrial continuous duty, are totally enclosed. Heaters are listed by UL and CSA.

Markel Electric Products, Inc., Buffalo, N. Y.

Channel Bar **(19)**

A new continuous-slot channel bar is fabricated in 10-ft lengths and known as Catalog No. 6029 from 16 ga; Catalog No. 6028 from 18 ga and Catalog No. 6027 from 20 ga steel. Channel bars are cold roll-formed with special rib design to provide structural strength. They are ¾ in. in height with an interior width of ½ in. and .281 in. continuous-slot opening. Continuous-slot feature permits unrestricted positioning of hanging devices—channel carriers, box fasteners, conduit clamps or ¼ in. sq nuts with threaded hanger rod. Channels are especially suited to suspended ceiling construction for hanging and support of lighting fixtures, outlet boxes and conduits.

Steel City Electric Co., 1207 Columbus Ave., Pittsburgh 33, Pa.

of the New No. C-12

RIDGID®

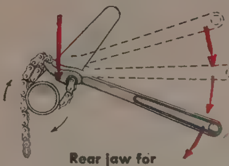
Utility Chain Wrench

Here's The Biggest Bargain In Its Price Class, Offering

1. **Maximum Capacity — ⅛″ to 4″ Pipe and Conduit**
2. **Double Jaw for Ratchet-like Action in Either Direction**

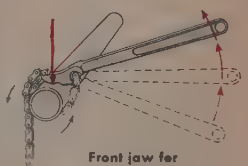
This rugged, yet light, utility wrench grips round, square and irregular shapes without crushing. Strong, flexible 15¾″ chain slips into tightest spots . . . has easy-to-grab end ring for fast chain adjustment. Strong, one-piece, 12⅞″ long, nickel-chrome plated handle and double jaw, made of forged alloy steel, give excellent leverage . . . with a maximum width of ¾″, it easily fits into narrow openings.

Order Yours Today for Only $4.95



Rear jaw for downward pressure.

Once attached, it's ready for fast, ratchet-like wrenching in *either* direction, without repositioning. Here's the perfect, low-priced answer for work close to walls or in parallel lines.

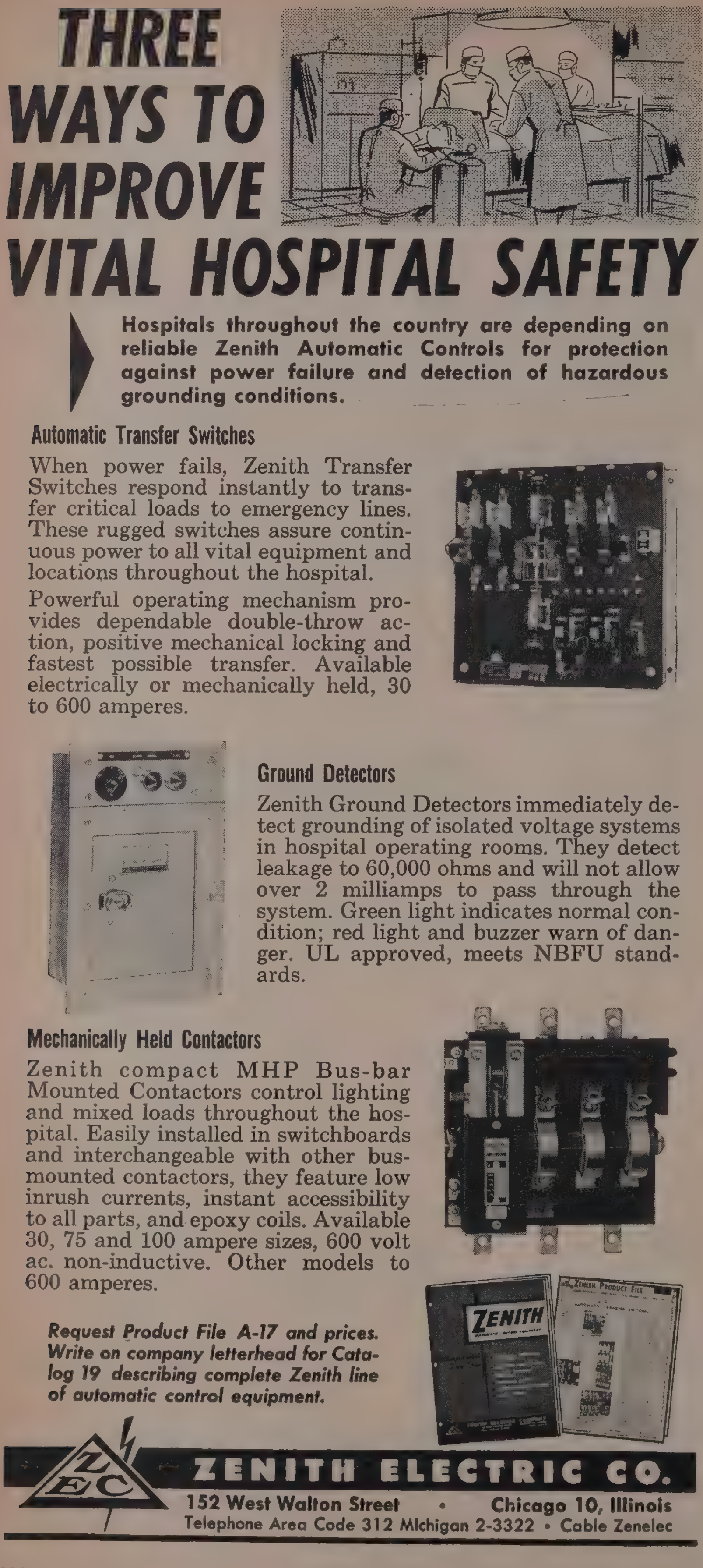


Front jaw for upward pressure.

Call your Distributor today. For your convenience, he maintains a complete stock of RIDGID Work-Saver Pipe Tools and parts.

RIDGID®

The Ridge Tool Company, Elyria, Ohio, U.S.A.



THREE WAYS TO IMPROVE VITAL HOSPITAL SAFETY

Hospitals throughout the country are depending on reliable Zenith Automatic Controls for protection against power failure and detection of hazardous grounding conditions.

Automatic Transfer Switches

When power fails, Zenith Transfer Switches respond instantly to transfer critical loads to emergency lines. These rugged switches assure continuous power to all vital equipment and locations throughout the hospital.

Powerful operating mechanism provides dependable double-throw action, positive mechanical locking and fastest possible transfer. Available electrically or mechanically held, 30 to 600 amperes.

Ground Detectors

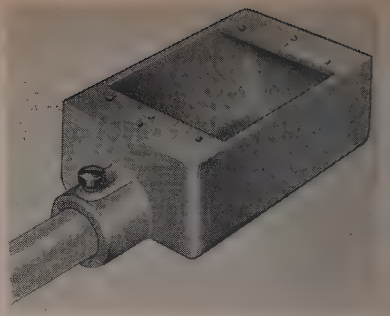
Zenith Ground Detectors immediately detect grounding of isolated voltage systems in hospital operating rooms. They detect leakage to 60,000 ohms and will not allow over 2 milliamps to pass through the system. Green light indicates normal condition; red light and buzzer warn of danger. UL approved, meets NBFU standards.

Mechanically Held Contactors

Zenith compact MHP Bus-bar Mounted Contactors control lighting and mixed loads throughout the hospital. Easily installed in switchboards and interchangeable with other bus-mounted contactors, they feature low inrush currents, instant accessibility to all parts, and epoxy coils. Available 30, 75 and 100 ampere sizes, 600 volt ac. non-inductive. Other models to 600 amperes.

Request Product File A-17 and prices. Write on company letterhead for Catalog 19 describing complete Zenith line of automatic control equipment.

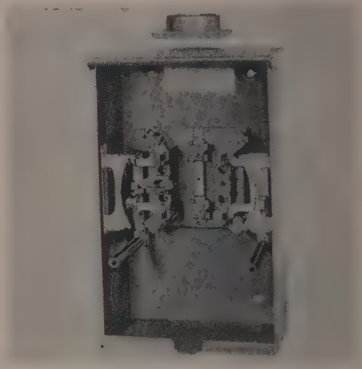
ZENITH ELECTRIC CO.
152 West Walton Street • Chicago 10, Illinois
Telephone Area Code 312 MIchigan 2-3322 • Cable Zenelec



Fittings (20)

The new Speed-O-Let line of electrical fittings carries one or more built-in connections. Installation requires the insertion of the thinwall or rigid conduit, and the tightening of the screw on each connection. Fittings are of copper-free, corrosion-resistant aluminum die-cast. Many types of fittings are available in the Speed-O-Let line, including switch boxes, entrance heads, pulling elbows and others.

Killark Electric Manufacturing Co., St. Louis, Mo.



Meter Sockets (21)

A complete line of 100-, 150- and 200-amp, 600-volt ac, general purpose ringless meter sockets are available in steel or aluminum for indoor or outdoor applications. They utilize extruded top ends to accommodate interchangeable die-cast raintight hubs. Hubs are UL listed and available from 1 in. through 2½ in. as are close-off plates. Fixed type hubs are also available as a standard item.

Anchor Manufacturing Co., Manchester, N. H.

Wall Bracket (22)

A new emergency prismatic wall bracket is engineered to provide light automatically the instant normal lighting current fails in hospitals, institutions, offices, restaurants, theatres, schools and other lo-

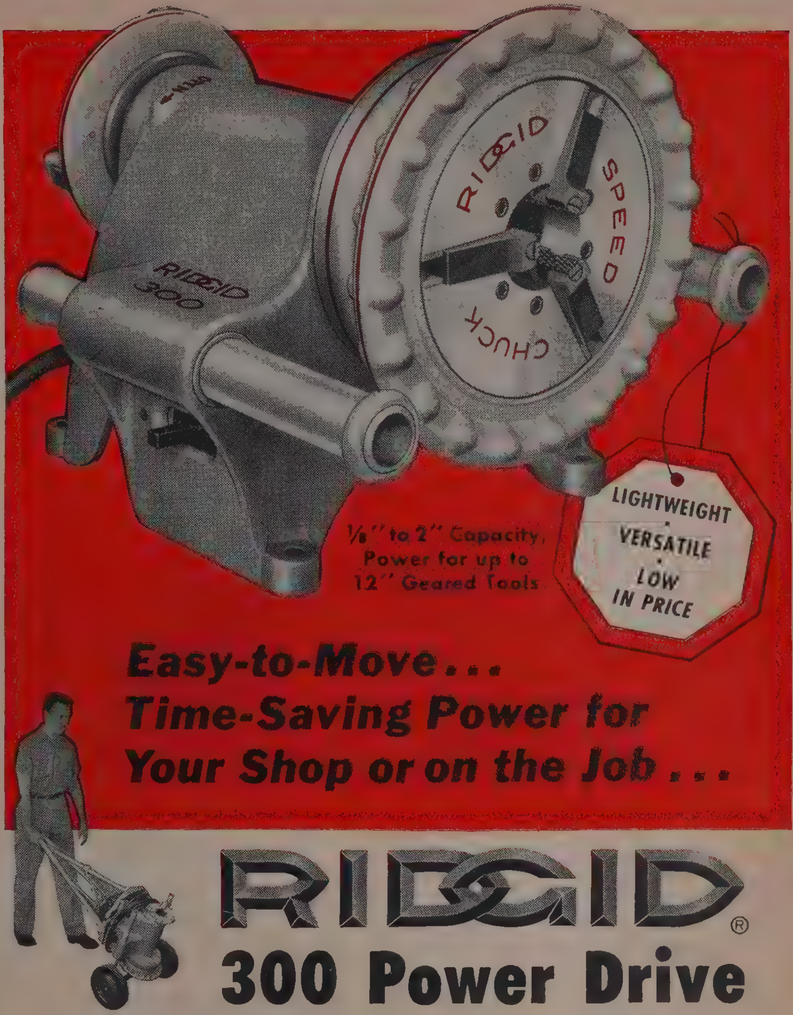
cations where uninterrupted service is desirable or mandatory. Fixture is equipped with two sockets: a standard adjustable 100-150-200-watt socket for regular use, and a low wattage secondary porcelain socket complete with separate wiring system for connection to remote emergency power supply. The die-cast aluminum line includes one and two light UL-listed weatherproof units for wall, ceiling, or custom pendant applications.

Stonco Electric Products Co., 333 *Monroe Ave., Kenilworth, N. J.*

Lighting Unit **(23)**

New wall- and surface-mounted incandescent lighting units with asymmetric arealenses have been announced. These weatherproof units, intended for outdoor use, refract light in a widespread fan-shaped pattern. They are for commercial, industrial and residential use. Wall-mounted unit is made of die-cast aluminum; surface-mounted unit is 18-gage aluminum. Units are designed for 150- or 200-watt lamps. Wall-mounted unit extends 9¼ in. from wall, height is 8⅝ in., width is $8\frac{5}{16}$ in. Diameter of surface-mounted unit is $7\frac{5}{16}$ in., over-all height is 7¾ in.

Art Metal Lighting Division, Wakefield Corp., 1814 *E.* 40*th St., Cleveland* 3, *Ohio.*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⅛" to 2" Capacity, Power for up to 12" Geared Tools
LIGHTWEIGHT • VERSATILE • LOW IN PRICE
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300 Power Drive

Bench, stand or truck mounted, this compact RIDGID 300 Power Drive quickly pays for itself in time and labor savings. Speed chuck closes and releases by hand . . . holds tight forward or reverse. Cam-action rear workholder holds even long lengths straight for perfect threads and cuts every time.

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Add the RIDGID No. 310 Carriage, No. 360 Cutter and a RIDGID Quick-Opening Machine Die Head, and you're ready to cut, thread and ream. With a No. 19 Nipple Chuck you even cut and thread close nipples with threading machine speed and ease.

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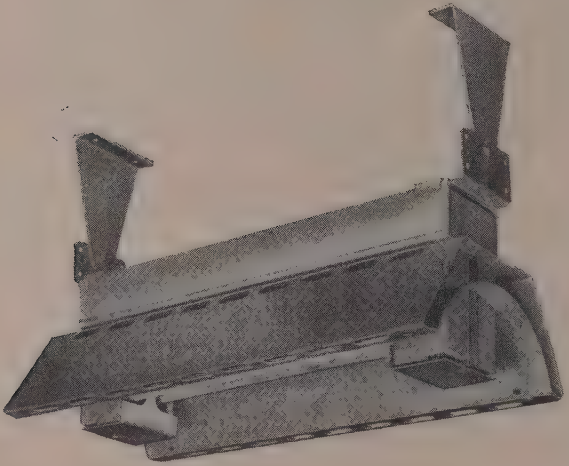
in Gold Medallion Homes
Equipped by General Electric

Sell packaged "sunshine" with General Electric's new radiant quartz heaters



Efficient, low-cost area heating, indoors *and* outdoors, instantly in any weather—this is what you can offer with the new General Electric radiant quartz heater.

This heater is similar to a small 'sun,' with infra-red energy that warms persons, objects, areas, regardless of temperature. The radiant quartz heater can be used anywhere, laughs at snow and ice, provides instant heat from energy that travels at the speed of light. Wide choice of mounting arrangements permits flexible heat direction.

The radiant quartz heater is offered with General Electric T3 quartz lamps, smallest and hottest electric heat source available, for 240/480v operation—and, with quartz tubes, for 120/240v installations. It's easy to install, and easier to sell!

Radiant quartz heaters are featured in the all-new General Electric line that brings you a 'supermarket' of electric comfort heating equipment—offers the right answer to every heating problem.

For details and specifications, write Sect. 280–06–1, General Electric Company, Electric Comfort Heating Section, Appliance Park, Louisville 1, Ky.

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Catalogs & Bulletins

(24) SCHOOL-LIGHTING LUMINAIRE, the Triumph, is described in product Bulletin SA-8864, including information about the choice of shielding, side panels, sizes, mounting and lamps. Westinghouse Lighting Div.

(25) METER CENTERS and accessories for multiple-metering applications are covered in 20-page Bulletin 9001-1A including photos, typical layouts and component tables of the new wall-mounted EQ meter centers and the recently introduced I-T-E Uni-Power free-standing metering switchboard lines. I-T-E Circuit Breaker Co.

(26) HIGH CAPACITY BUSWAY SYSTEMS designed for plug-in or feeder applications where heavy loads are served, or where low-voltage drop or reduced available short-circuit current values are required, are described in 24-page Bulletin GEA-6736. Distribution Assemblies Dept., General Electric Co.

(27) FLOODLIGHTING. Baseball and softball floodlighting recommendations are discussed in 68-page catalog including installation data such as the minimum mounting height for floodlights, and suggestions for the particular type and number of floodlights required for specific applications. Benjamin Div., Thomas Industries Inc.

(28) PUMP MOTOR REPAIR Booklet B-8606 describes repair facilities and processes. Apparatus Repair Div., Westinghouse Electric Corp.

(29) EMERGENCY LIGHTING. 16-page booklet entitled "How to Select Emergency Lighting" gives step-by-step instructions for planning emergency light installations. Carpenter Mfg. Co., Watchmaster Div.

(30) TERMINAL BLOCKS. 16-page catalog describes complete line of more than 373 terminal blocks including new fully insulated feed through and new track-type blocks. Curtis Development and Mfg. Co.

(31) GROUNDING. "Down to-Earth Facts on Grounding Portable Electrical Equipment" explains NEC's safety specifications for the design and connection of grounding devices. Harvey Hubbell, Inc.

(32) Speed Drives. Bulletin 2200 describes ac-dc variable speed drive packages for 1/6 to 20 hp motors which consist of a magnetic amplifier control panel, a patented solid-rotor ac motor and a manual speed-control potentiometer. Fidelity Instrument Corp.

(33) Cable. Multi-conductor flat flexible cable, which permits space savings of up to 7 to 1 and weight reductions of up to 10 to 1, is discussed in 8-page Booklet S-10. International Resistance Co., Plastic Products Div.

(34) Motor Control Centers. Using the firm's Unitrol center as a model, 48-page "Motor Control Center Handbook" (LJ-1) explains the concept, design and application of motor control units and includes basic structure and electrical wiring provisions, and rating and size data. Cutler-Hammer Inc.

(35) Terminals and Connectors are described in 68-page catalog including data on terminal boards and on various automatic devices for attaching terminals. Ark-Les Switch Corp.

(36) Photoelectric Relays. Bulletin SCW-136 describes versatile, high-speed photoelectric relays activated by light increase or decrease. General Electric Co.

(37) Service Entrance Breaker (Type QCC) is described in 4-page Booklet B-7634 including features, applications and dimensions. Westinghouse Electric Corp.

(38) Housepower. Revised catalog of Housepower Promotion Materials contains descriptions, illustrations, prices and ordering information on all currently available advertising, promotion and sales aids, designed exclusively for use in promoting the sales of residential wiring modernization. National Wiring Bureau

(39) Electric Comfort Heating. 8-page catalog describes complete line of flameless electric heating equipment designed for every room of the home. Electromode

(40) Capacitors. Design features of the new lightweight line of extended foil capacitors, which are available in 25-, 50- and 100-kvar sizes, 2400 through 7960 volt ratings, and either single or double bushing, are described in Bulletin 32C9421A. Allis-Chalmers Mfg. Co.

Hamron* hits savings on the head!

A hammer, a second, and Anderson's exclusive new Hamron* are all you need to make a perfect connection every time!

Hamron Lugs and Splices cover a cable range from #6 through 300 MCM

Hamron Lugs and Splices are the simplest yet developed. Unequalled in pull-out strength and electrical conductance. Eliminate special tools (a hammer and a flat surface are all you need). A few blows form connector and cable into virtually one solid unit. "Hamron" cannot over compress . . . the deformed punch shows it is a tight connection. Maintenance free. It adds up to big savings in time, labor, tool costs!

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2 x 8 dressed fir in 10 seconds

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Wood and metal turn to butter faster . . . with the new B&D power-packed Sabre Saw. Tests prove it cuts through 2x8 dressed fir, ¼-inch angle iron and 2-inch pipe conduit all in less than a minute . . . almost twice as fast as any saw its size! Greater power, new long-stroke action (cutting surface is over 1″) make the difference, put more teeth into every job (assure less blade wear).

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Choose from a complete new line of Sabre Saw blades—double-edged for pockets and scrolls, single-edged for any job. They fit all other leading saws, too . . . make them cut faster. Buy the new B&D Sabre Saw with five all-purpose blades at leading distributors everywhere.

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In the News

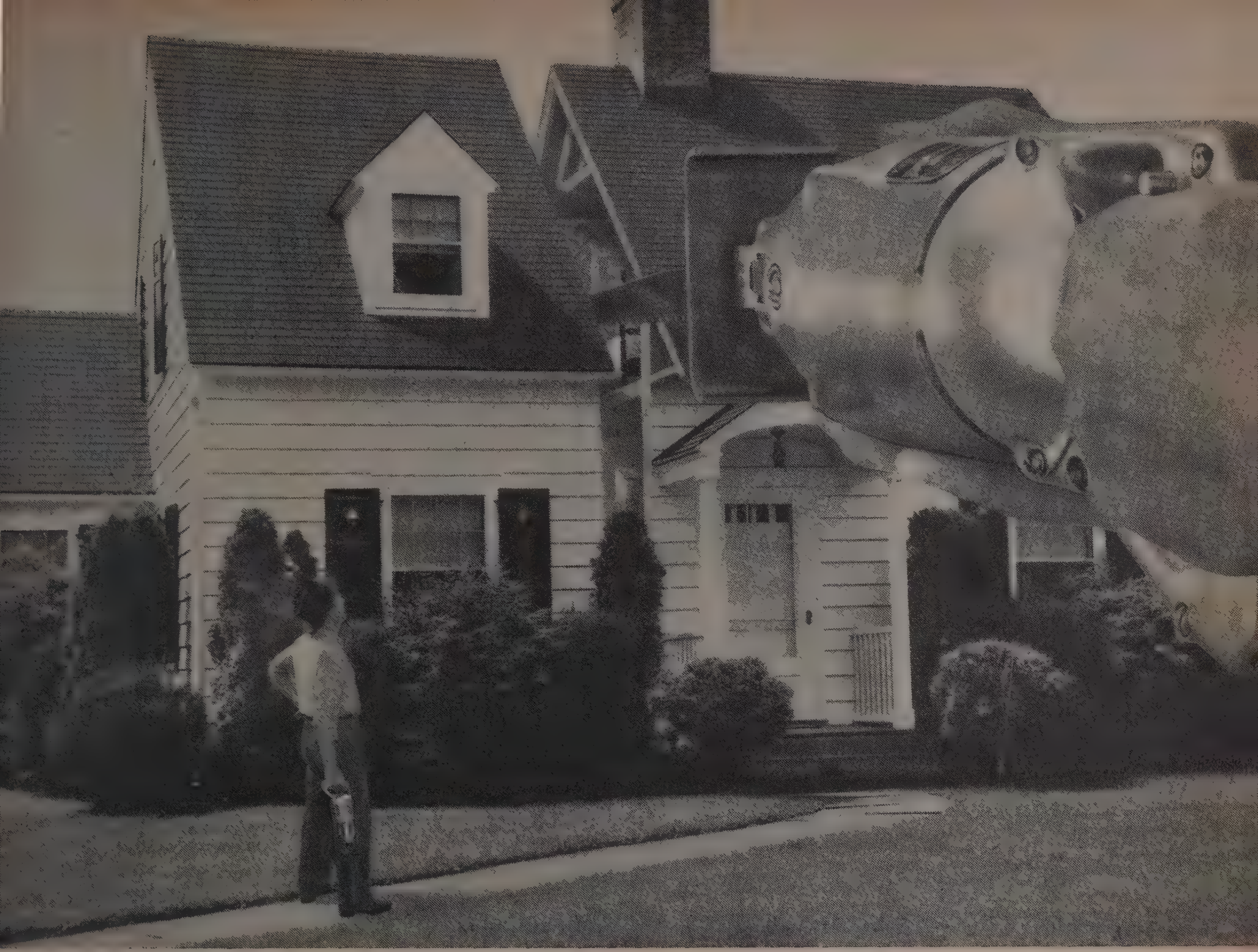
California EMEA Focuses Spotlight on Maintenance

The Electrical Maintenance Engineers Association of California held their 8th biennial Electrical Industry Maintenance Conference and their 11th related Exhibition in Los Angeles, March 28-31; six panel programs over a 4-day span were devoted to Maintenance, Codes and Lighting. Panelists included electrical contractors, consultants, inspectors, maintenance supervisors and manufacturer representatives; over 20 speakers being introduced by General Chairman K. Lee Alvey of AiResearch and Program Chairman Mike J. Boyak of Stetson Electric during the meetings. Active question periods defined all sessions. And, in keeping with the basic nature of the Conference, over half of the discussions considered such maintenance-related problems as engineering, contract work vs in-plant crews, cost controls, electronic equipment, scheduling, plus-factors and limitations of all-out maintenance programs in both large and small industrial plants.

The largest attendance was attracted to a session on code discussion, although by far the most animated floor discussion was generated by contractor K. W. Busch, who contended that industrial maintenance is a major management responsibility; that it is a service function trapped between opposing desires to lower product costs, raise workers' wages and yet obtain a reasonable profit margin; and that maintenance is a field wherein outside contractors can insure operational continuity to an equal or even higher degree than can in-plant crews. In promoting maintenance-by-contract, Busch cited more than two dozen "claimed" benefits, including such factors as diversity of labor demand, availability of specialists required only occasionally, questions of tool and instrument inventories and replacements, insurance, storage, shop facilities, labor rates and job responsibility. He likewise related maintenance to modernization, stating that systems should be kept up-to-date to preclude obsolescence, and suggesting that all improvements should be studied for safety, load handling capacity, power factor, voltage fluctuations, changing plant layouts and demand, utility rates and practical economy.

Echoing the importance of maintenance was Arnold R. Jahn, senior electrical repair foreman in the L. A. Dept. of Water & Power's general plant division, who cautioned against carrying preventive measures to unrealistic extremes. In this thesis he contrasted routine and emergency work, urged maximum cooperation between production and maintenance supervisors, stressed the importance of preplanning and scheduling, and advocated complete replacement of complicated control equipment rather than trouble-shooting with insufficient equipment and knowledge. To illustrate possibilities of abuse, Jahn cited numerous examples to indicate how inefficiencies and damage could result from inadequate inventories, lack of records, poor planning, neglected inspections, lack of cooperation, over-insulating or over-lubricating.

CODE EXPERTS on forum panel of code session at recent Upper Midwest Electrical Industry Convention in Minneapolis included: (L to R) moderator H. B. Love, Detroit, member CMP 6; R. L. Lloyd, Washington, D. C., chairman CMP 4; Frank Stetka, Chicago, secretary of correlating committee, NFPA National Electrical Code Committee; R. W. Osborn, contractor, St. Louis, Mo., and chairman CMP 1.



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New B&D Sabre Saw with longer cut goes through wood, metal, plaster

It stops at nothing! The new Black & Decker Sabre Saw power-cuts clean through wood and plaster, metal pipe and sheet . . . all as easy as you please with exclusive long-stroke action. Unique rock 'n' lock shoe design makes your work easier yet. Blade spindle turns 90° and 180° to cut in any corner, cut out any pocket. You grip right behind the safeguard blade guide for up-front control. You'll find the Sabre Saw's vibration is the lowest ever . . . its balance perfect for the most accurate cutting. Just try the new B&D Sabre Saw one time . . . and you'll see how it *could* cut a building in two, any time.

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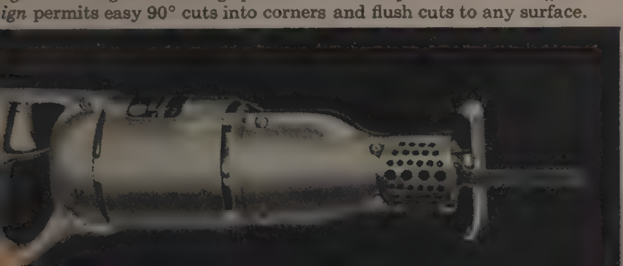
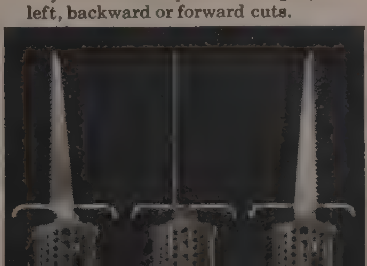
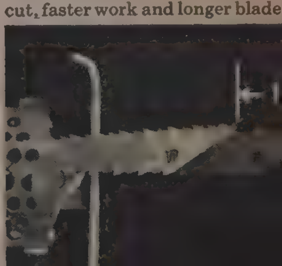
feguard blade guide allows grip close to cut for up-front control. *Offset-*
ign permits easy 90° cuts into corners and flush cuts to any surface.



Adjustable blade spindle for right, left, backward or forward cuts.



Long-stroke action provides a cle
cut, faster work and longer blade



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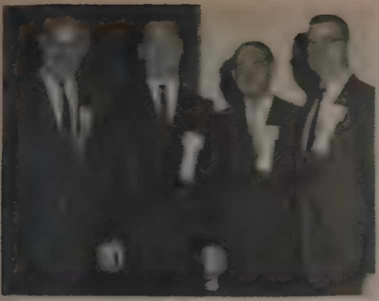
Maintenance Costs Related to Downtime

Several speakers stressed the importance of preventive maintenance by citing exorbitant costs related to power interruptions and resulting downtime of production lines. For example, John L. Pahlow, plant engineer for the Jos. Schlitz Brewing Co., stated that idle labor due to their packaging conveyors being halted amounts to $100 per minute, and, five years ago, collective downtime on all assembly lines averaged an hour per shift, a labor loss of $18,900 per day or $4.7-million annually. Of this total, about half of the stoppages were attributed to electrical failures (motors, relays, switches, electronic timers, photocells). Today, however, thanks to a preventive program, electrical interruptions have been reduced 85%, labor savings amounting to $2-million annually. Pahlow then reviewed their program of records, analysis, changing types of motors, tube replacement, motor rewinding with new insulations and installation of controls in waterproof cabinets.

Frank E. Hamlin, Marquart Corp's. plant engineering and services department, likewise equated maintenance charges pertaining to group lamp replacement as opposed to individual service for single burnouts. Stating that his plant contains over 5700 lighting fixtures in 19 buildings, he showed how group lamp replacement had reduced per-fixture relamping times from 40 minutes to 6, then he reviewed Marquart's maintenance program relating to cleaning of lamps and fixtures, inspection of ballasts and starters, compilation of records and circuit drawings. Hamlin included factors affecting selection of numerous circuit com-

PLANT MAINTENANCE techniques and practices were discussed at Los Angeles EMEA Conference by panel consisting of K. W. Busch of Busch Electric; Arnold R. John, Dept. of Water & Power, City of L. A.; C. Leon Perry, Columbia-Geneva Steel Div., U. S. Steel Corp., moderator, and David L. Dehlinger, Larson Hogue Electric.



CODE INTERPRETATION and proposed changes were subjects for discussion by Moderator Arthur G. Clark, Dept. of Building & Safety, City of Los Angeles; Danny Jackson, Vancott Electric Co.; Edward V. Muller, State of California Div. of Industrial Safety, and Donald S. Newswanger, Dept. of Building and Safety. Panel appeared on 4-day program of California EMEA.

ponents which could affect costs by reducing essential maintenance work.

Cost controls, reviewed by Robert J. Goss, RCA manager of plant engineering, were credited with numerous savings for that corporation, since he claimed that record analysis had revealed many instances where maintenance procedures should be augmented, multiplied or changed. Examples included citations of incorrect nameplate data on a speed reducer; use of remote controls and recording ammeters to protect motor windings; up-rating of motors in horsepower or speeds to satisfy specific load conditions; the fallacy of overlubrication and more thorough training of workers entrusted with complicated electronic controls. "Managerial knowledge and operational skill is primary," he maintained, then concluded by citing cost savings which could be obtained by higher quality standards, job instruction, planning and scheduling, practical methods, training, human relations, thorough investigation of failures and recommended administrative procedures.

Electronic Equipment Considered

Tips on maintenance of electronic equipment and numerically controlled devices were offered conference delegates by three speakers: George W. Haven, Electronic Maintenance Co.; Robert Miranda, Convair Div. of General Dynamics, and Herb Sellers, Kaiser Steel Co.

In this coordinated presentation, Haven concentrated upon tools and techniques, recommending such basic instruments as volt-ohm-milliammeters, vacuum tube voltmeters, tube testers and good qual-

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Protect your reputation and build your business by giving your customers the finest in quality, dependability and long service life; install Arrow-Hart Wiring Devices on all your jobs! For complete information, see your local Electrical Wholesaler today . . . or write direct to the Arrow-Hart & Hegeman Electric Co., Dept. ECM, 103 Hawthorn Street, Hartford 6, Connecticut.

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WIRING DEVICES • ENCLOSED SWITCHES
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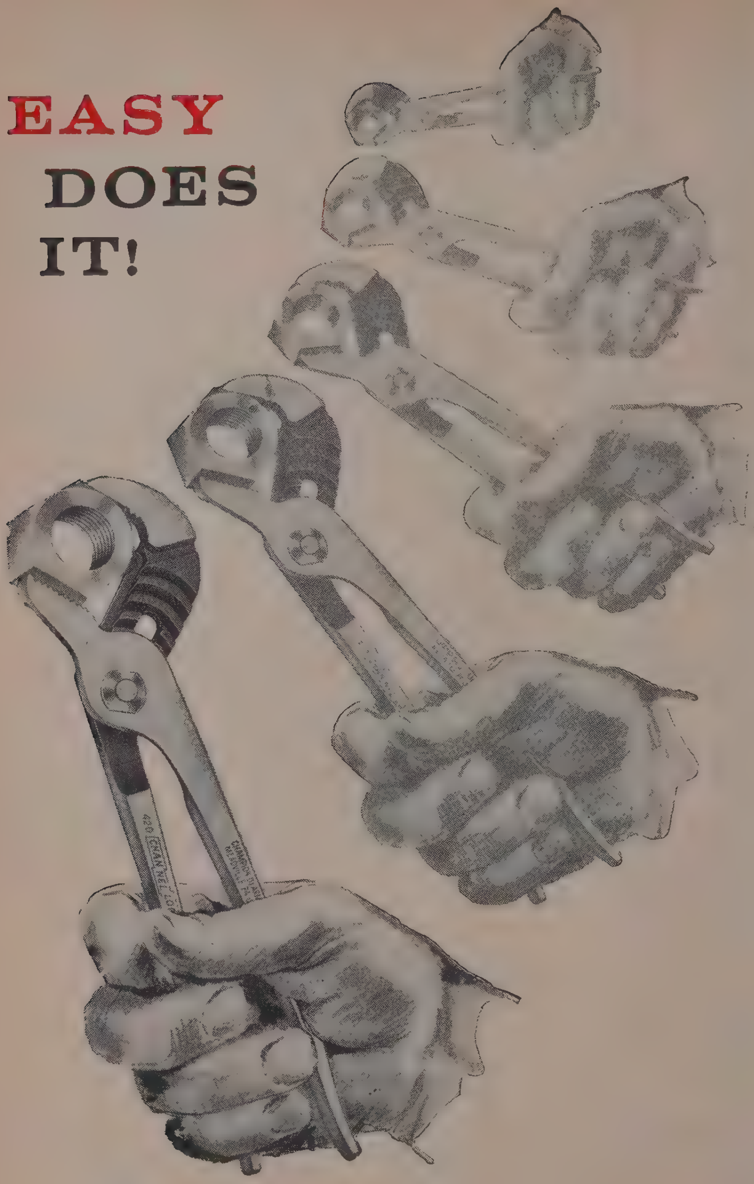

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ELECTRICAL MAINTENANCE Conference in Los Angeles was programmed by Mike J. Boyak, Stetson Electric, and chairmanned by K. Lee Alvey of AiResearch.

ity oscillographs. Concerning techniques, he discussed specific examples for cleaning and inspecting controls, tubes, relays and switches, wiring and connections, summarizing by stating that reliable electronic service demands good tools and instruments plus education, knowledge and common sense.

While agreeing with these basic requirements, Miranda added that efficiency of electricians can be created or stimulated by incentives, desire and proper training courses, illustrating that contention by reviewing how his company selects and instructs men for specific assignments, promotes from within, organizes maintenance programs, advocates many types of training and refresher courses, prepares step-by-step check-lists as service guides, subscribes to adequate instrumentation, and advises workers of the importance of their jobs and of the sizable costs involved in errors and resulting downtime.

Herb Sellers' remarks related directly to electronic maintenance in large steel plants, where assignments range from service of regulators and communication systems to overhead cranes, circuit breakers, commutation problems, closed-circuit television systems, X-ray thickness gauges and assemblies involving photosensitive relays. Handling this scope of assignments calls for several gradations of skills, he maintained, a fact which prompted recent creation of new electronic craft groups to handle specific classes of equipment. Sellers advocated limiting responsibility to as few persons as possible, pinpointing special talents to preclude confusion, over-lapping or omissions in servicing electronic devices.

Practical Tips for Contractors

Electrical contractors in attendance were particularly interested in discussions by David L. Dehlinger, Larson-Hogue Electric, and by Danny Jackson, Vancott Electric. Dehlinger's remarks pertained to re-rating motors through design and insulation changes, while Jackson's discussion considered industrial system installation methods.

Dehlinger considered only re-rating of common 3-phase squirrel-cage induction motors, relating horsepower to speed, torque, flux, centrifugal forces, bearing life, rotor and fan construction. He then discussed winding and relative back-iron thicknesses required for 2-, 4- and 8-pole stators, indicating that re-rating can also be attained by increasing allowable temperatures permitted with modern, stable, more efficient insulations.

Jackson's talk indicated that contractors who are called into plants for initial maintenance purposes can obtain multiple benefits for themselves as well as customers by recommending system improvements for existing installations. Busways, underfloor duct systems, covered cable trenches, single metering and power factor correction were several illustrations enumerated, and Jackson also cited installation economies which would be obtained through use of new tools such as CO_2 gas cylinders for cleaning conduit and shooting fish-lines; elevating workbenches used in conjunction with separate scaffolds; electric conduit benders; rotary-impact drills; C-frame hydraulic knockout cutters; reel dollies and gas-activated hoists.

As mentioned earlier, the largest attendance was attracted by a session on codes, wherein Edward V. Muller from the State of Calif. Div. of Industrial Safety discussed reasons behind up-coming changes in both the National Electrical Code and Calif. Electrical Safety Orders, while Donald S. Newswanger, elec-

PRE-CONFERENCE HUDDLE takes place at EMEA podium between Lighting Moderator Urban Beh (right), Los Angeles Consulting Engineer; and panelists E. W. Michel of Westinghouse and Arthur G. Hess of Hess, Greiner & Polland.

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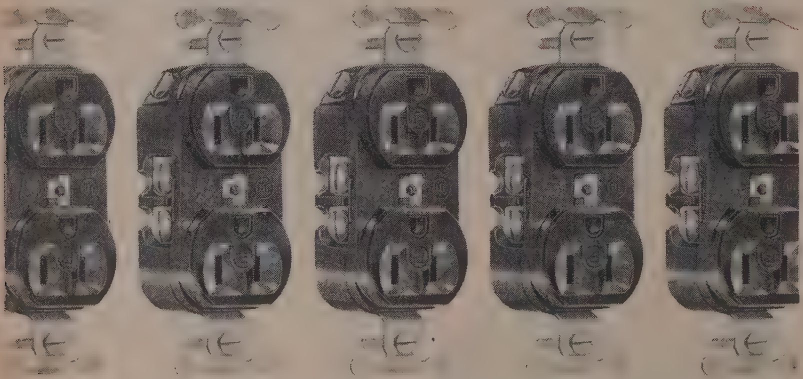
CIRCLE F **3-WIRE "U" GROUND** RECEPTACLES RUN CIRCLES AROUND ALL OTHERS...

COMPARE THEM!



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Designed to meet every requirement of the new National Electrical Code and for use with either metallic or non-metallic wiring systems, Circle F's line of new 3-wire grounding type receptacles matches every specification. All contacts are spring bronze and double wiping and the "break-off" score on the terminal link permits 2-circuit installation. Large #8-32 binding screws with cut slot heads and ⅞" box screws with plaster-cleaning threads and cut slots mounted in the strap make installation fast and easy. Precision engineering, quality controlled production and rugged construction guarantee customer satisfaction, while Circle F's low prices guarantee more profits. All Circle F 3-wire grounding type receptacles are listed with UL and CSA.

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ELECTRICAL INDUSTRY SHOW, staged concurrently with biennial conference of California EMEA, was directed by Charles H. Hays, Electrical Estimators, Inc.

trical engineer, Los Angeles Dept. of Building and Safety, reviewed proposed amendments in the L. A. 1962 code pertaining specifically to machine wiring, tools, presses, testing devices, extruders, woodworking machines and similar heavy duty equipment. Both talks cited specific examples where changes would be pertinent, tables and sketches being used to clarify applications where motor ratings, starter sizes, overcurrent protection and wire dimensions would be altered by new rulings.

Higher Lighting Standards

Lighting discussions likewise prompted high levels of interest, consulting lighting engineer Urban Beh reviewing industrial lighting progress and optical processes relating to vision, E. W. Michel from the west-coast lighting div. of Westinghouse reviewing precepts pertaining to proper selection and layout of fixtures, and Arthur J. Hess of Hess, Greiner & Polland equating lighting to air conditioning.

In this round-up, Beh referred to current IES research programs which are providing scientific foundations for higher footcandle recommendations and he also reviewed such vision-related factors as color, reflected glare and polarization of light.

In discussing fixture layouts, Michel considered higher accepted standards, higher wattage lamps, higher efficiencies, higher accepted voltages and higher lumen outputs leading to the development of new lamp applications, new fixture designs, new photometric curves and new coefficients of utilization and visual efficiency.

With higher intensities being prescribed and accepted, new heat problems are arising, said Hess in his talk, and this is directly affecting air cooling requirements and design considerations. However, lamp heat can be used advantageously to heat buildings in many instances, he maintained, while cooling of fixtures can be achieved by circulating exhaust air or water through or around lighting troffers, with thermostats and dampers regulating amounts of troffer exhaust which are to be recirculated or conveyed out of buildings.

On the final day of the conference two Maintenance Clinics were conducted on Productive Maintenance of Electronic Motor Control Systems, and a parallel session on Static Controls. Both sessions were repeated twice, these presentations considering actual trouble-shooting methods associated with controls, saturable reactors, rectifiers and magnetic amplifiers.

The concurrently staged Electrical Industry Exhibit, presented under the chairmanship of Charles H. Hays, Electrical Estimators, Inc., displayed products and services of some 100 manufacturers and distributors. Certificates of Merit were presented to Alcoa's Rome Cable Div., Harvey Hubbell, Inc., and The Rigid Tool Co. for presentations judged for effectiveness, useful informational or instructional value. Judges included Ralph Hoover, Hughes Aircraft, Ernest Nelson, Chicsam Co., and Charles Keeble, Union Pacific Railroad. Show promotion was directed by Henry Bush, Littlejohn-Reuland Corp.

EASA News

Carl W. Sievert of the Sievert Electric Co. family, which has produced two international presidents of EASA, was recently elected president of the Cook County (Chicago) Electrical Contractors Association. He is the son of Carl A. Sievert and brother of Paul M. Sievert, both former heads of EASA.

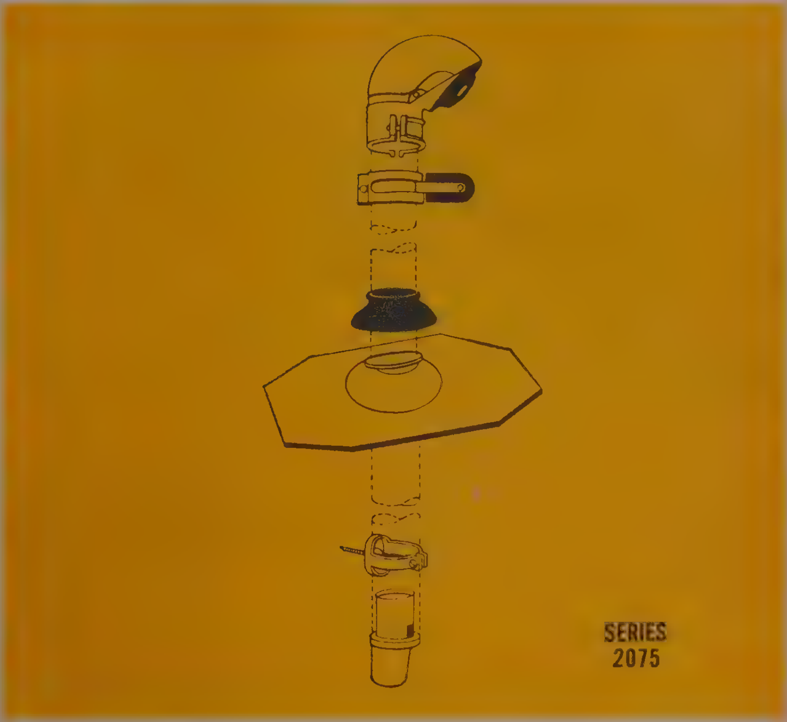
• • • •

Charles Werner, son of Otto Werner, immediate past-president of EASA's Great Lakes Chapter, was recently praised in a feature story in the *Detroit Free Press* for volunteering to teach at Franklin School in one of the city's juvenile delinquent problem areas. A graduate of Wayne State University, young Werner supplements his teaching income by working part-time at the family motor repair shop, Werner Electric Co.

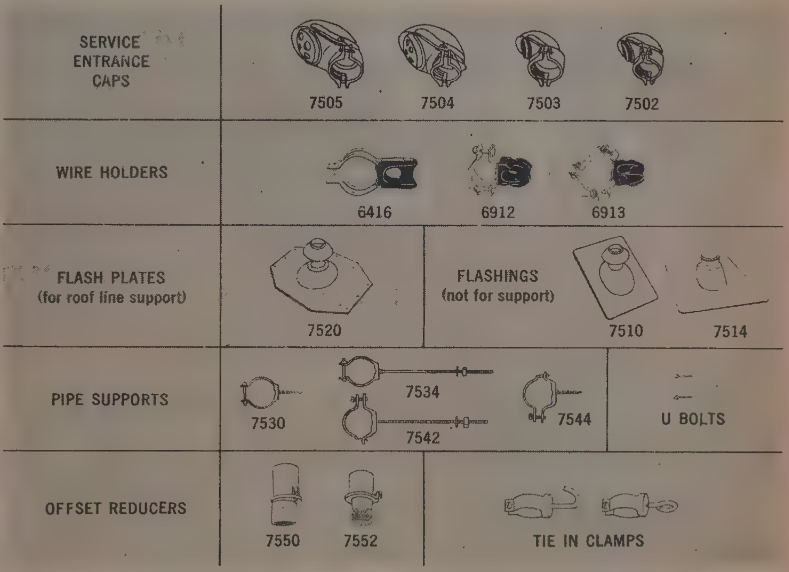
• • • •

Another Detroit motor service

PORCELAIN PRODUCTS MAST KITS
ENGINEERED FOR TODAY'S BUILDING NEEDS



OPTIONAL PARTS TO MEET EVERY REQUIREMENT



Standard and special mast kits, plus a wide range of optional parts and accessories, combine to make Porcelain Products Co. your "one-stop" mast kit supplier. Since service entrance masts first became a necessity, Porcelain Products mast kits have been used and trusted by electrical contractors the country over. For additional information, or for assistance in engineering special kits, write . . .

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PAT. PENDING
FLEXIBLE VENTILATED CONDUIT
. . . the labor-saving, copper saving, versatile Ventilated Cable Suspension System!

CHECK THESE ADVANTAGES:
- No Installation Equipment Needed!
- Saves Time, Cuts Labor Costs!
- Designed for Flexible or Rigid Use!
- Outperforms Old-fashioned Methods!
- Full Free-air Ratings Possible!

Unique, lightweight LINE-FLEX offers obstacle-avoiding flexibility in one plane and non-sag rigidity in the other! Requiring NO special equipment, tools or training to install, it can be used in non-supported rigid lengths of up to 14 ft., or in catenary applications of up to 400 ft. **INSTALLS IN UP TO 25% LESS TIME!** Several hundred feet of cable may be pulled through up to **three** 90° bends **by a 2-man crew without damage or distortion.** AND—the free-air ratings obtainable mean even bigger savings!

Available in 2", 3" and 4"-dia. Zinc-coated Cold-rolled or Stainless Steel; full line of fittings and accessories. **WRITE FOR CATALOG.**

LINE-FLEX
DIVISION OF
PERFECT-LINE MFG. CORP.
HICKSVILLE, NEW YORK

A VARIETY of persons interested in the servicing and maintenance of plant electrical equipment stopped at the EASA exhibit at the Plant Engineering & Maintenance Show, held at Convention Hall, Philadelphia, January 22-25. Above, Thomas Marino, a member of EASA's Quaker City Chapter, Marino Electric Co., Philadelphia, shows a rewound stator to Alex Malko Jr., electrical inspector at the Naval Air Turbine Test Station, Trenton, N. J.

shop figured in the news recently when George Karabetian, an electrician employed at Standard Electric Motor Works, was reunited with his elderly mother, Mrs. Esther Karabetian after a separation that dated back to 1943 when Mr. Karabetian was marched off to a labor camp in Germany from the family home in Armenia. It was necessary for Michigan Senator

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Need precise regulation? The Richardson-Allen line provides constant voltage or constant current with your choice of saturable reactor, magnetic amplifier or transistor silicon controlled regulation.

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Send for literature today to solve your conversion power problems.

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☐ Bulletin 1300A, Selenium Plating and Anodizing Power Supplies
☐ Bulletin 801, Silicon Plating and Anodizing Power Supplies
☐ Bulletin 1401, General Purpose Battery Chargers

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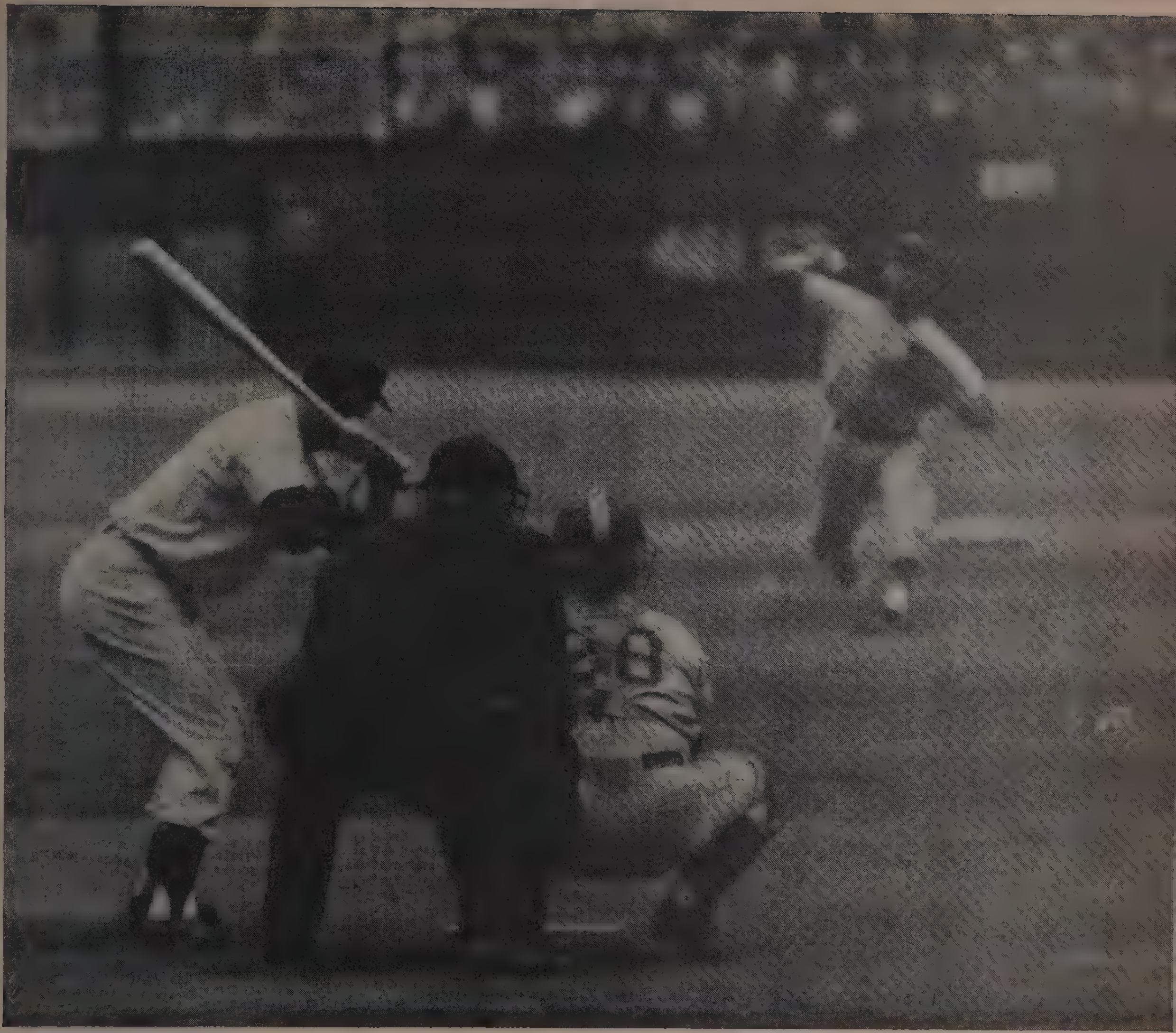

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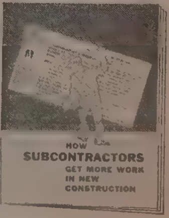

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P&K

LIGHTING STANDARDS WITH

Luminaire Lowering Mechanism

for convenient GROUND LEVEL MAINTENANCE

Now, P & K lighting standards are available with this new approved mechanism — ideally suited for locations inaccessible to maintenance equipment or where such equipment is not available for any reason. Thus, to the maintenance free strength and beauty of P & K all-aluminum standards, you enjoy the economy and convenience of ground level relamping or service.

The lowering mechanism, model LM-1, is available with P & K single and twin arm standards with truss arms up to 15 feet. It can be used to support incandescent or mercury vapor luminaires, pendant type, and bail or yoke suspended single or twin floodlights.

For helpful technical data, write for 6-page catalog LM-1.

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GEORGE H. BROWN, partner in the newly formed B&H Wire & Insulation Co., Phoenix, Ariz., visits the Electrical Apparatus Service Association exhibit at the Electrical Insulation Conference in Washington, D. C., held February 19-22.

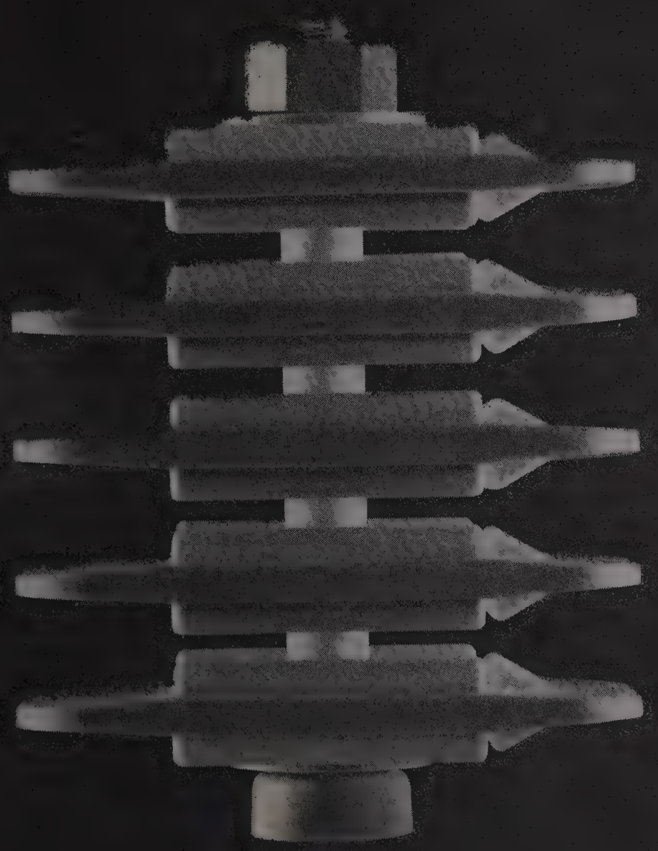
Philip A. Hart to intercede with the Russian authorities in Mrs. Karabetian's behalf before she was given permission to come to the U. S. to live with her son and his family. Mr. Karabetian is termed "an excellent worker" by employer S. S. Moran.

• • • •

Nearby, in Toledo, Ohio, another motor shop executive was praised over the air for providing new jobs for the community through the creation of industrial parks.

He was Stanley Romanoff, president of Ontario Equipment Co. Editorials broadcast over WSPD and WSPD-TV recently told of Mr. Romanoff's ability to combine profitable enterprises with civic betterment. "His approach is simple," the editorial read in part, "Bargain for a good buy. Scout for tenants (preferably ones who can use the products Mr. Romanoff sells). Keep the rent low, or sell at a low mar-

AT THE EXHIBIT of Lenni Products, Lenni Mills, Pa., Charles L. Johnson, Charleston Electric Supply Co., Charleston, W. Va., visits William Weirich, owner of the Lenni company. The occasion was the recent Electrical Insulation Conference held last February 19-22 in Washington, D. C.



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AND BULLDOG XL® BUS DUCT JOINTS ARE LOCKED TIGHT UNDER A TON OF PRESSURE ! ! KEYED BUS BAR ENDS ALIGN AUTOMATICALLY. FAST . . . SAFE . . . DEPENDABLE. CONTACT YOUR LOCAL I-T-E SALES OFFICE TODAY . . . . .IMAGINEERING THROUGH ELECTRICITY.

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QUIET DRY TYPE
TRANSFORMERS

Dongan has specialized in the manufacture of dry type transformers for more than 50-years. This length of service to the electrical industry assures you of high quality, dependable transformers. Carefully built to your requirements, they will give long, quiet service.

DONGAN DRY-TYPE TRANSFORMERS are made in both Class B 80° Cent. Rise and Class H 150° Cent. Rise. Single phase transformers, 25 V.A. to 100 KVA; three phase, 3 KVA to 300 KVA. Suitable for indoor or outdoor applications. Designed for wall or platform mounting. All have roomy wiring compartments.

Sizes 5 KVA and larger feature tap-changing and voltage-changing terminal board equipped with solderless connectors for speed hook-up. Built to meet or exceed NEMA specifications.

Dongan also makes transformers for-signaling-machine tools-control-buck and boost-high voltage secondary for oil and gas burners-neon signs.

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RETURNING to the EASA board as a director after an absence of three years was William W. Saunders, Lenawee Electric Co., Adrian, Mich., (left), shown here with C. S. Moran, Standard Electric Motor Works, Detroit, Mich., whom Mr. Saunders has succeeded.

gin. Help the tenant move and buy needed equipment. Plow the profits back to repeat the whole process. The results are community growth and new or better customers for Mr. Romanoff's prosperous firm."

• • • •

A popular EASA leader in Columbus, Ohio, has changed jobs. Don Osenbaugh, formerly service manager of J. L. Hughes Electric Co., has joined Butcher Electric Co., San Jose, Calif., in a managerial position.

• • • •

Formation of a special committee to keep government advised of the needs for critical materials of the electrical apparatus service industry is under consideration by EASA's Executive Committee. During World War II as well as during

OBSERVING a Kenco Pump display installed at the EASA exhibit at the Plant Engineering & Maintenance Show, held January 22-25, at Convention Hall, Philadelphia, are, from left James Previty, Penn Electric Motor Co., Philadelphia, president of EASA's Quaker City Chapter; Milton Eisenhardt, owner of a motor repair firm named after him, Pensauken, N. J.; and Bruce Bender, Kufen Electric Motors, Warminster, Pa.

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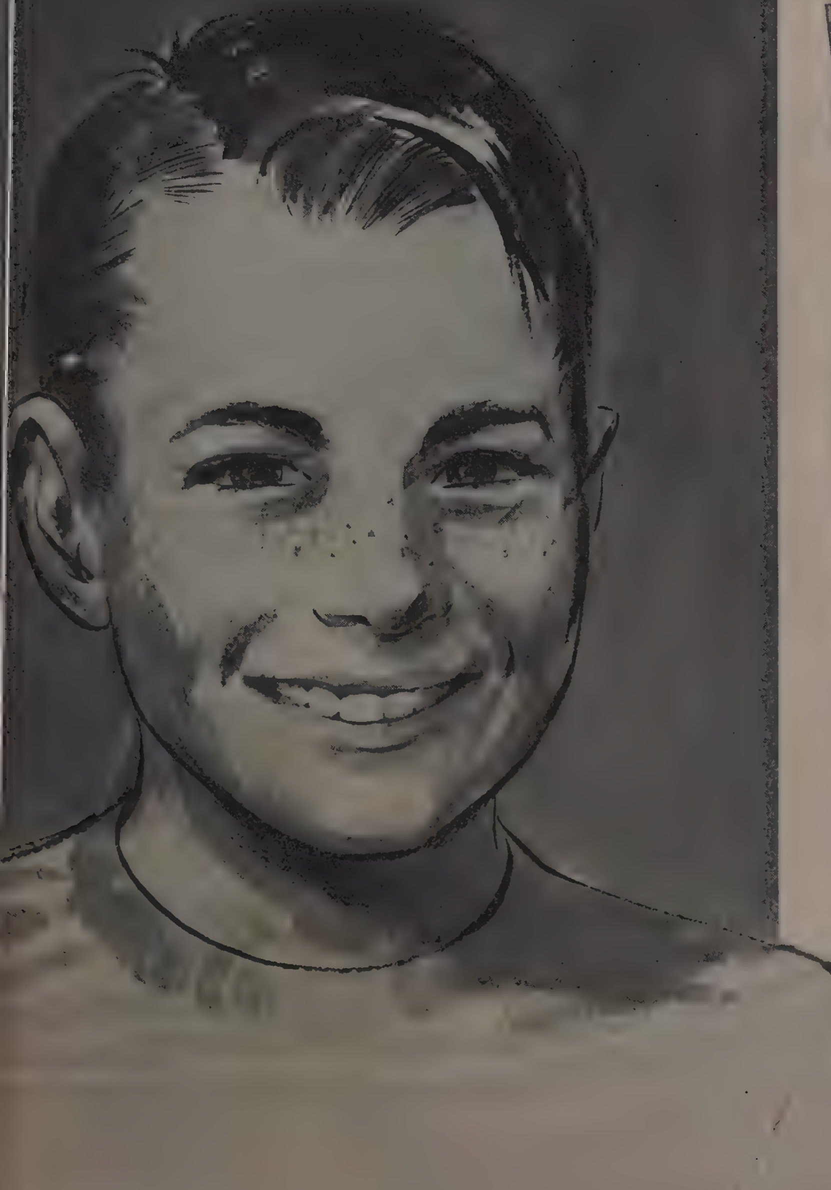
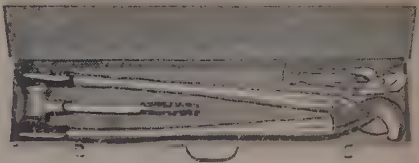
Who stay young with T&B products . . . who come home with a spring in their step and ready for fun.

We really can't promise that T&B products will make you a kid again . . . But you'll feel better in all ways when you see how tough jobs can be made easier. Here are a few of our products that will add extra quality to wire handling and send you home with a smile.





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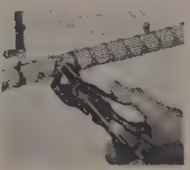
Everything for bending — slicing — stripping cable. Bend cable up to 750 MCM, slice cable to 1,000 MCM and strip cable from #1 to 1,000 MCM.



TY-RAP™ CABLE TIES AND STRAPS

Six times faster than tying with string — low cost installation can be done by tool or hand. Wide range of TY-RAPS for tying, clamping, mounting and identification.

STA-KON® TERMINALS

Industry's most complete line of insulated and non-insulated terminals #26 — 250 MCM. Ring tongue, forked tongue, wire joints, splices, disconnects and flag.

WT100M installs #22 — #10 wire range.

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LUGS, TAPS, JOINTS AND CONNECTORS color-keyed for instant selection by wire size. One tool installs the whole range #8 AWG through 500 MCM.

Exclusive T&B compression method insures permanent, low-resistance connections.

On your next "wire handling" requirement check with one of our authorized distributors in your area — he'll have what you need to do the job right.

Write for our complete catalog of electrical construction products.

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The only competitively priced quiet switch with both screw and E-Z Wire® pressure terminals

Now you can meet both low-budget and premium quality requirements with this new EAGLE Toggle-Type Residential Quiet Switch. It operates on famous Eagle patented principle that provides "fast makes" and "slow breaks" through automatic mechanical action . . . not hand movement. Single pole and three way. Plaster ears. Takes #14 or #12 wire. *Has extra common terminal connections for continuous wiring.* For use in any position with all standard wall plates. Individually packaged in cellophane-wrapped Eagle "SHO-PAK". Also bulk packed on special request. Single Pole: No. 1021B – Brown; No. 1021V – Ivory. 3-way: No. 1023B – Brown; No. 1023V–Ivory. 15 AMP–120V–AC only. Meets Fed. Specs. Also available in TOUCH-A-MATIC types. Write for FREE sample and literature.

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DEPT. 5, 23-10 BRIDGE PLAZA SOUTH, LONG ISLAND CITY 1, N. Y.
"PERFECTION IS NOT AN ACCIDENT"

POST-SESSION huddle at recent Minnesota Electrical Association meeting in Minneapolis finds Earl Sorg (left), Hastings Electric, Hastings, Minn., and Melvin Rixman, Southside Electric, Minneapolis, discussing contractor problems.

the Korean emergency, the association was successful in obtaining priorities for copper wire and other items under federal controls.

• • • •

Ralph Mollet, vice-president of Flushing Electric Co., Flushing, N. Y., has been named "EASAN of the Month" by the association. He recently retired after two terms as president of the association's New York Metropolitan Chapter. He started in the industry in 1923 as an apprentice at The Maintenance Co.

• • • •

A number of EASA chapters have elected new officers for terms ending next spring.

They are:

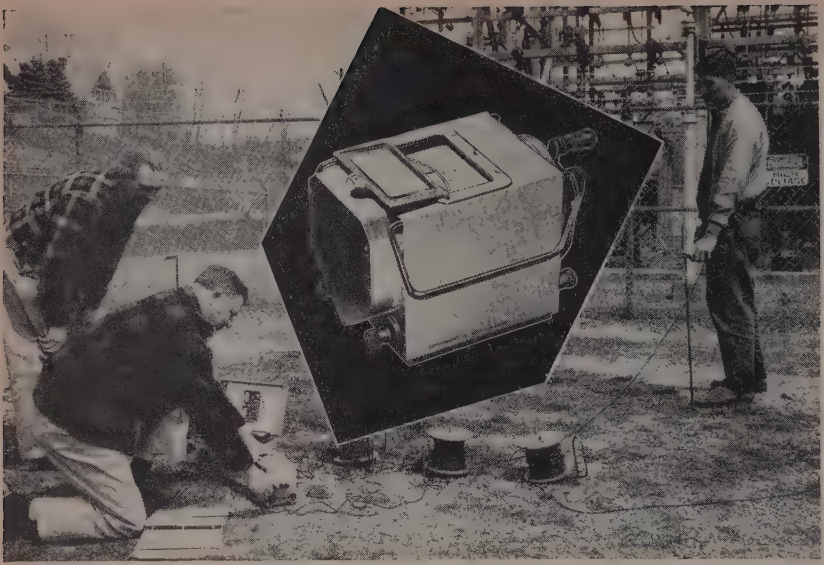
Wisconsin Chapter: president, Carl Wojahn, Badger Armature Service, Waupan, Wis.; vice-president, James Koenig, Koenig Electric Co., Milwaukee, Wis.; and sec-

ELECTRICAL CONTRACTOR S. J. Berquist, Litchfield, Minn., tells Electric Heating Forum at recent Upper Midwest Electrical Industry Convention in Minneapolis that family living habits should be considered when designing an electric home heating system. Otherwise, customer may be dissatisfied with operation and costs.

How?—by stopping heat before it starts. An exclusive blade design keeps the arc from the contact area. There's no burning or beading. One-piece copper construction eliminates joint heating. Tin plating stops heat caused by corrosion and wear. Results: the switch stays cooler, lasts longer.

Other valuable Westinghouse features include the De-ion arc quencher and visible blades. These long-lasting safety switches have been tested at 100,000-amp fault currents with current-limiting fuses. Get all the reasons why Westinghouse switches are preferred for rugged applications. Ask your local Westinghouse distributor or salesman for information, or write Westinghouse Electric Corporation, Standard Control Division, Beaver, Pennsylvania. *You can be sure . . . if it's Westinghouse.* J-30335

Westinghouse



UTILITY PREVENTS ELECTROLYTIC CORROSION—RELIES ON MEGGER® GROUND TESTER

Worcester County Electric Company's underground cable system in central Massachusetts was the target of severe corrosion caused by low ground resistance to stray electrical currents, until laboratory tests revealed the situation.

After acting quickly to repair the corroded sections, the utility embarked immediately on a preventive maintenance program to stop further deterioration. The program was built around continuing tests with a Megger Ground Tester, selected because of the speed, ease and accuracy it provides in obtaining readings.

After a year's use, Worcester Electric finds that the Megger Ground Tester gives these advantages:

1 *It functions at all times*
2 *It does not have to be balanced*
3 *It does not require a power supply*
4 *It requires a minimum of maintenance*
5 *It takes rapid, accurate readings*

Savings attributed to the Megger Ground Tester preventive maintenance plan run into thousands of dollars per year. Worcester Electric is now able to spot areas of low resistance in their cables sufficiently in advance of actual breakdowns so that complete counteracting measures can be taken.

DO YOU HAVE THIS INFORMATION FILE ON GROUNDING?

The James G. Biddle Co. File 25 is an excellent fund of information on grounding problems. It includes a manual on Ground Resistance Testing, and bulletins on "Grounding Electrical Circuits Effectively" and "Grounding Principles and Practices Applied to Industrial Plants."

Write Now for Your Copy of Ground Testing File 25ECM.

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Electrical & Speed Measuring Instruments
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UL'S JOB is to get safe equipment into the hands of the public, Merwin Brandon, president, Underwriters Laboratories, Inc., Chicago, tells huge audience at recent Upper Midwest Electrical Industry Convention Code Session in Minneapolis.

retary-treasurer, Ray Chafee, Industrial Motor Service, Racine, Wis.

Western Michigan: president, Norman Vliek, Rowen & Blair Electric Co., Kalamazoo; vice-president, John Weeks, Weeks Electric Co., Grand Rapids; secretary-treasurer, Ernie Crook, Beall, Gibson & Roush, Kalamazoo; Paul Bogdan, Clement Electric Co., Grand Rapids, and Robert Rape, L. R. Klose Electric Co., Kalamazoo, Mich., directors.

Quaker City: president, George McDaniels, Kufen Electric Motors, Warminster, Pa.; 1st vice-president. Thomas diMarino, Marino Electric Co., Philadelphia; second vice-president, George Wagner, Wagner Electric Service, Philadelphia; treasurer (reelected) Milton Eisenhardt, operator of a firm under his own name in Pensauken, N. J. Executive committee members include James Previty Jr., Penn Electric Co., Philadelphia; Walter Gibson, Buckley Electric Co., West Atlantic City, N. J.; and C. Bernard Hull, Neuhauser, Inc.

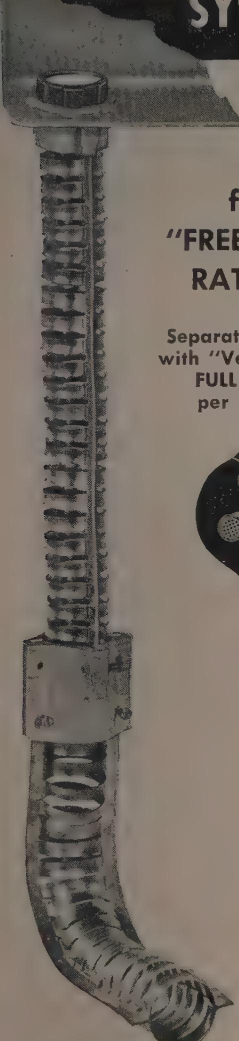
Great Lakes: president, Chris Palmer; 1st vice-president, Bill Lugar; 2nd vice-president, Joe Bilicki; secretary (reelected) Charles Smith; treasurer, J. R. Watterson; and Bill Cotter and Bill Howard, directors.

Chicago: president, William Luebeker, Hyre Electric Co.; vice-president, William Kaska, Chicago Electric Co.; secretary, Walter W. Hendricks, Hendricks Electric; treasurer, Leroy Nettgen, Arthur Wagner Co.; J. G. Lessel, Robert Ferrari, Clarence Jepperson, James Beals, John J. McKenna, Abe Marcus and Zigmond Pluskota, directors.

"LATROBE" PRODUCTS

FULL-FLEX CABLE SUSPENSION SYSTEM

RIGID OR FLEXIBLE



for "FREE AIR" RATING

Separators used with "Ventilated" FULL FLEX per inset.

The "FULL-FLEX" Cable Suspension System is a modern method of permanently, or temporarily suspending electrical cable in Industrial, Mining and other applications. It offers *complete* flexibility or non-sag rigidity. Simplicity of installation, maintenance, inspection . . . at lower cost.

"FULL-FLEX" may be used for rigid installations up to 14 feet on channel center lines, or as catenaries up to 400 feet or more.

Actual installation example—using 3" "FULL-FLEX", 80 feet long (one piece), with two 90° bends, four 30° bends and support on six channels, 14 feet apart, accomplished in four man hours.

"FULL-FLEX" hangers and clamps fit standard slotted channels.

Furnished in 2", 3" and 4" diameters—galvanized or stainless—100 ft. coils, on reels. "FULL-FLEX" is bent by hand and cut with a hack saw.

PIPE OR CONDUIT HANGERS

No. 470 Series

The saddle or pipe support can be turned 360°, permtting pipe to run parallel or at right angle.
Made of highest grade malleable iron, with case hardened set screw —all cadmium plated. Also made in high tensile strength Aluminum. Sizes ½" thru 2½".
Excellent for confined areas. No drilling, no use of straps.

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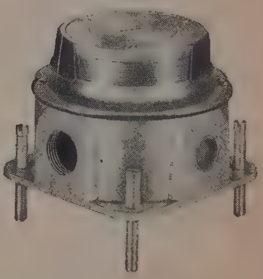
No. 190

ADJUSTABLE STEEL BOX

Steel Box with a 3¼" diameter brass cover plate. There are two ½" and two ¾" KO's in sides and two ¾" and three ½" KO's in bottom. Comes in two standard heights —3⅛" and 2⅝" minimum. Designed for power or telephone service.



No. 122

CAST IRON BOX

Adjustable Floor Box with cast iron box body. Contains all the same advantages, receptacle adaptability, etc., as found in Fullman's No. 190 series steel-bodied floor boxes. Brass or Aluminum Top Assemblies to go with nozzles at no extra cost.

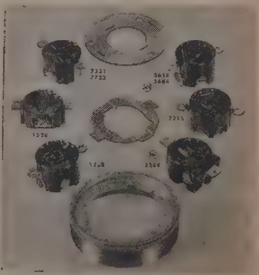
FLUSH TYPE NOZZLE

No. 307 Series

This new compact, modern, attractive, streamlined Receptacle and Telephone Nozzle comes in brass (lacquered) or anodized aluminum. Not die-cast nozzles, but drawn of heavy stock. They are made single or double (back-to-back) and include 1" nipple.

Height 2⅜"—Width 2⅜"—Length 3½" One inch shorter in length than standard under floor duct nozzles.

Visit Booth 711 N A E D Convention—May 13-16
Pittsburgh Civic Auditorium



Adjusting ring for our No. 122 and No. 190 series is so designed that "KEY" (shown in center of photo) drops easily into special slots. You select the receptacle required and simply "LAY-IN"; then "LAY-ON" receptacle ring. This has been added at no extra cost.

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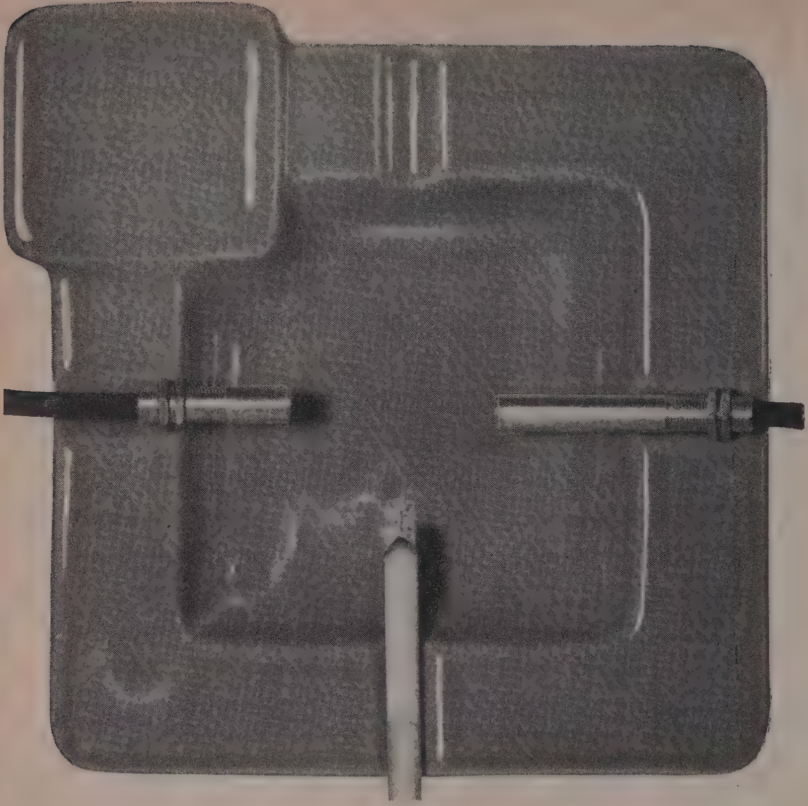

New micro-miniature units . . . latest additions to General Electric's full line of photoelectric controls

New micro-miniature light sources and receivers add new versatility to General Electric's full line of photoelectric controls and sensing devices. Measuring only $3/8$-inch in diameter, the light source and receiver are designed for use where space is a problem. Easily installed, and requiring no focusing, they will deliver exceptional performance for many applications. The light source is rated up to 20,000 hours; the solid-state receiver delivers almost infinite electrical life.

General Electric offers a full line of photoelectric devices and systems for every job; also voltage-, or resistance-sensitive relays, a smoke-density indicator, radiant-heat detector, and electronic timers. For complete information, write for General Electric's new "Photoelectric Control" bulletin, GEA-6822, General Electric Company, Schenectady, New York. 793-07

Specialty Control Department, Waynesboro, Virginia

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GENERAL ELECTRIC

COMPARING THREE basic types of snow-melting systems, Iain Campbell, Easy-Heat, Inc., New Carlisle, Ind., tells recent Upper Midwest Electric Heating Forum in Minneapolis that low-watt density heating cable is the most economical and efficient system.

Cable Makers See Import Threat

The insulated wire and cable industry "approves the broad objective of expanding the export trade of the U. S." but is of the opinion that it is at a substantial disadvantage in attempting to compete with foreign manufacturers in either foreign or domestic markets "in view of the major cost advantages possessed" by overseas wire and cable companies.

Thus C. W. Higbee, consultant to the Wire and Cable Division of NEMA speaking at the Division's meeting in Absecon, N. J., on April 17, commented on the industry's viewpoint toward current tariff proposals. He cited a list of eight safeguards to "provide effective import relief to domestic industries in appropriate cases."

He challenged the effectiveness of the Administration's proposals not only on the prevailing cost disadvantage of American producers, but cited several prevalent restrictions engaged in by foreign countries, aside from tariffs, including "grandfather" clauses, refusal to provide bidding information and other devices which prevent U. S. companies from offering bids to foreign purchasers, usually agencies of their governments.

In the economic outlook the lag in investment is rapidly becoming this nation's number one domestic problem, reported Martin R. Gainsbrugh, chief economist of the National Industrial Conference Board. He cited a lower-than-average rate of recovery from the February 1961 trough in the business cycle and a long term decline in the corporate profit rate.

C. H. Bartlett, vice president, Westinghouse Electric Corp., told the conference that nuclear power will "certainly become competitive in the 1960's in the high cost fuel areas of the country for large size generating units."

Also, he continued, EHV—the transmission of electric energy at extra high voltages over long distances "will encourage interconnection and pooling" and "move larger blocks of energy more economically and efficiently through congested areas."

Baltimore Local 28 Reinstated in IBEW

After a long and bitter controversy including complex litigation in the Federal Courts, Baltimore Local 28 has been reinstated in the IBEW.

Local 28, last year, called a strike in defiance of IBEW constitutional procedures without the approval of International President Gordon Freeman. Its charter was revoked and charges brought against 15 officers and members of the Local before the International Executive Council of IBEW.

An opinion was handed down on March 7 by Judge Thomsen of the U. S. District Court of Maryland which called for reinstating Local 28 but allowed limited disciplinary action against responsible officers and members by IBEW.

Subsequent action by the IEC expelled A. L. Eveson, president, and J. Beckhardt, business manager of Local 28 from the IBEW. Certain other officers and members were barred from attending meetings or holding office for various terms.

PRACTICE SAFETY urges electrical contractor Elroy Lehn, Anoka, Minn., at Minnesota Electrical Association conference in Minneapolis. Lehn is vice chairman of the electrical section of the Minnesota Safety Council.

EVEREADY PRECISION ENGINEERED CORE DRILLS

POWER...
SPEED...
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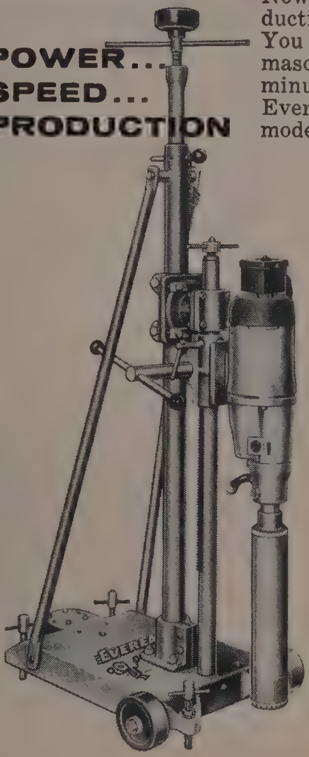
Now you can have all the Power, Speed, Production you need and want in a Core Drill. You can drill holes in reinforced concrete, masonry materials, stone, refractories . . . in minutes. Choose the precison-engineered Eveready Core Drill you need. There's a model for every drilling application.



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Full 360 Degree, Any Angle Drilling
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Dual-Column Design and Column Stabilizers

Eveready Super Duty CD-180-360 Degree, any angle drilling for holes up to 14" in diameter. Equipped with a 2-Speed, Super-Duty 18-Ampere Power Unit. Change speeds instantly with a shift of the lever. Instant choice of the most efficient speed for the size of the bit and the material to be drilled. Develops up to 3½ H.P. rated load at speeds of 210 RPM and 550 RPM. 115 Volt or 230 Volt. High-strength aluminum housings.

Special heat treated gears. Thermal Motor Protector eliminates motor "burn-out". Overload Clutch protects motor, gears, and bit. Built-in water swivel assures ample, even flow of water to the bit. Easily attached Vacuum Hold Down Unit.

Heavy Duty CD-120—has all special and exclusive features of the Super Duty CD-180 except comes equipped with 2 Speed, Heavy Duty, 12 Ampere Power Unit for drilling holes up to 8" in diameter.

Compact CD-100—for drilling holes up to 4½" in diameter. Equipped with special 10 Ampere single-speed power unit. Gear change kit available. Develops up to 1⅓ H.P. High strength aluminum housings . . . ventilated for cool operation . . . heat treated gears. Motor can be removed and converted to hand held drill with purchase of optional Handle Kit . . . Thermal Motor Protector . . . Adjustable Jack Screw for vertical bracing.

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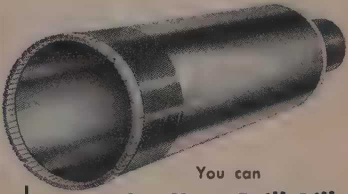

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New Books

Standard Refrigeration and Air Conditioning Questions and Answers, by Stephen M. Elonka and Quaid W. Minich; 253 pages; $6.95. McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N. Y.

A practical introduction to air conditioning and refrigeration in a variety of industries, directed to operating and servicing personnel and students of trade, vocational, and technical institutes. Emphasis is on basic equipment and theory.

Industrial Control Instruments, by B. Chester Delahooke, $4.75. Delmar Publishers Inc., Albany 5, N. Y.

Principles and application of pressure and temperature controls such as bourdon tubes, pressure gages, bellows elements, controller mechanisms, graphic manual systems, and thermoelectric devices, with illustrations and complete descriptions. Included are chapters on basic control theory, temperature effects, and absolute, gage, and differential pressures.

Industrial Process Control, by B. Chester Delahooke and Leslie M. Zoss; $5.75. Delmar Publishers Inc., Albany 5, N. Y.

Intended for use by plant personnel who require knowledge of the basic principles of instrument application. Two major parts of the book treat fundamental control theory and applications of control processes. Basics include discussions of such concepts as the closed loop, system stability, step response, and frequency response. Specific industries covered include food canning, freezing, and dehydration; milk production; sugar processing; pulp and paper; textiles; the brewing industry; and air conditioning.

Automatic Control of Heating and Air Conditioning; Second Edition, by John E. Haines; 375 pages; $10.50. McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N. Y.

Devoted to the fundamentals, selection, and application of automatic control devices. Basic principles are introduced and illustrated, followed by analyses of controls and circuits and their integration into complete systems. New chapters in this edition include electronic control units, electronic control circuits, control of domestic air conditioning, and control of peripheral distribution units.

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HERMETICALLY SEALED MERCURY SWITCH

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Simple to install and easy to wire. An adapter plate is provided for mounting thermostat directly to a standard wall switch box. All wiring is quickly made by means of a terminal block located on back of thermostat

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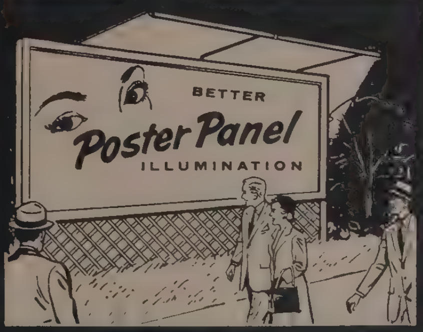

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Electrical Contracting, by Ray Ashley. 294 pages; $10.00. McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N. Y.

A companion volume to the author's *Electrical Estimating*, this book is intended for the electrical contractor desiring to increase his business by more efficient management and understanding of his field. Among the problems covered are: how the man contemplating the electrical contracting business can appraise his own qualifications; how much it will cost to get started; how much it will cost to maintain the business until it is self-supporting; how much business will be needed to warrant continued operation; the man-power problem; the necessary functions of a well qualified contractor; how to select the better contracts; how to make the most of contracts obtained. Additional chapters deal with operating costs, conducting overhead-cost studies, writing proposals, conducting labor-cost studies, and training apprentices.

30 Instruction Units in Basic Electricity, by C. E. Matson; 127 pages; $1.70. McKnight & McKnight Publishing Co., Bloomington, Ill.

A complete course of study, outlined step-by-step. Theory is presented simply, and each instruction unit contains a job or operation in which the theory is used or tested.

American Electrician's Handbook; Eighth Edition, edited by Clifford C. Carr and Terrell Croft; 1676 pages; $17.50. McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N. Y.

A comprehensive reference to the design, installation and maintenance of electrical construction and equipment for the practical electrical worker. All sections and most illustrations have been revised; all material is in accordance with the 1959 National Electrical Code.

Proceedings of the Sixth Conference on Magnetism and Magnetic Materials; 309 pages; $10.00. McGraw-Hill Book Co., 330 W. 42nd St,. New York 36, N. Y.

A set of 149 papers presented at the 1960 annual Magnetism Conference sponsored by the American Institute of Electrical Engineers and the American Institute of Physics. They provide a comprehensive review of the current state of all aspects of theory and practice.

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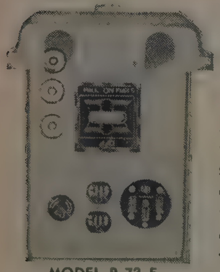

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Covers close completely while in use and can be padlocked to eliminate tampering.

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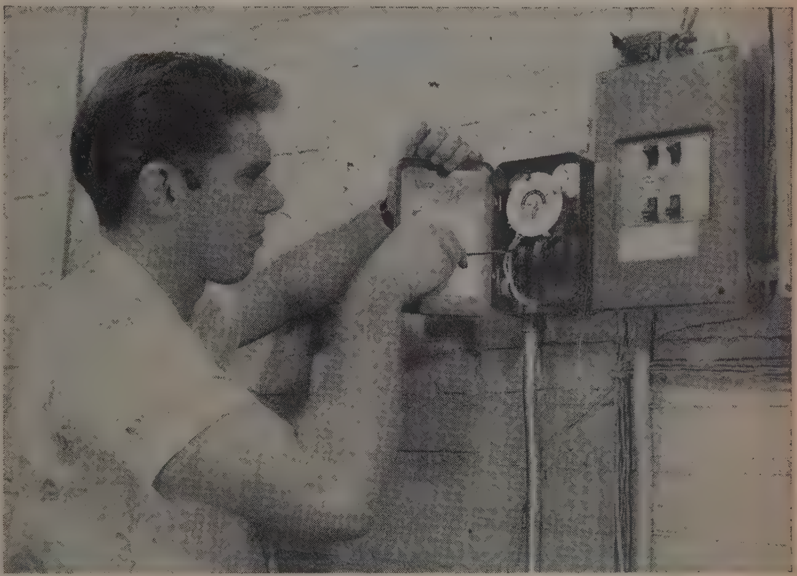

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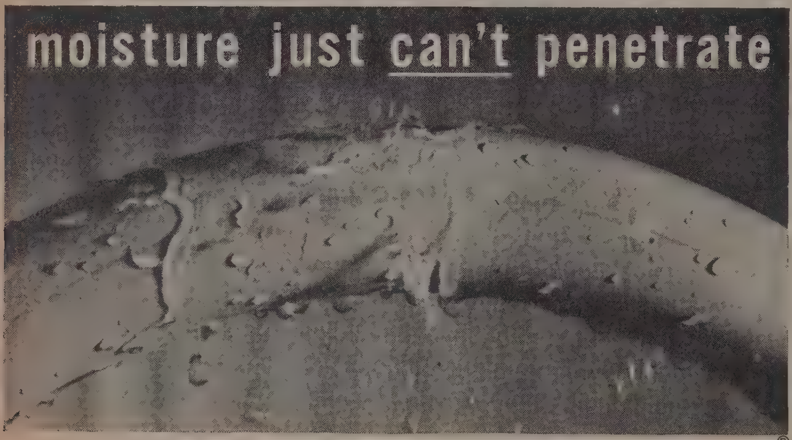

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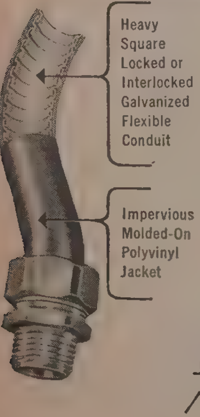
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DATES AHEAD

Illuminating Engineering Society — Regional Conferences — **Midwest/North Central**, Radisson Hotel, Minneapolis, Minn., May 10-11; **Canadian**, Winnipeg, Man., May 14-15; **Pacific Northwest**, Davenport Hotel, Spokane, Wash., May 17-18; **South Pacific Coast**, U. S. Grant Hotel, San Diego, Cal., May 21-22; **Inter-Mountain**, Western Skies Hotel, Albuquerque, N. M., May 24-25; **Maritime**, Charlottetown Hotel, Charlottetown, P. E. I., June 8-9; **Northeastern**, Hotel U. S. Thayer, West Point, N. Y., June 11-12.

National Association of Electrical Distributors — Convention, Pittsburgh, Pa., May 12-16.

Pacific Coast Electrical Assn.—Annual convention, Ambassador Hotel, Los Angeles, Calif., May 16-18.

National Fire Protection Association—66th annual meeting, Sheraton Hotel, Philadelphia, Pa., May 21-25.

Edison Electric Institute—Annual convention, Atlantic City, N. J., June 4-6.

Electrical Apparatus Service Association—Convention, Conrad-Hilton Hotel, Chicago, Ill., June 10-13.

National Society of Professional Engineers—Annual meeting, French Lick Sheraton Hotel, French Lick, Ind., June 13-16.

International Association of Electrical Inspectors — Chapter Meetings — **Virginia**, Hotel John Marshall, Richmond, Va., June 18-19; **Southern Section**, Tutwiler Hotel, Birmingham, Ala., October 15-17.

Los Angeles Home Show — Memorial Sports Arena, Los Angeles, Calif., June 21-July 1.

American Society of Heating, Refrigeration & Air Conditioning Engineers Inc.—69th annual meeting, Deauville Hotel, Miami Beach, Fla., June 25-27.

N. Y. State Assn. of Electrical Contractors & Dealers—Annual convention, Whiteface Inn, Lake Placid, N. Y., July 2-7.

ENGROSSED IN CODE discussion during Western Section, IAEI convention in Oklahoma City are electrical inspectors K. R. Anderson, Clayton, Mo.; and Edward LaPointe, Minnesota State Board of Electricity, St. Paul.

Unretouched "after" photo shows *Sno-Melter* at work in South Bend!

WINTER 1962:
Here's pictorial proof of the promise, "No more snow to shovel" on walks, drives, ramps, shipping docks which are Sno-Melter equipped! Snow-free walk in front of modern McGann Securities Co. offices, South Bend, shows where electric Sno-Melters were installed months ago.

SUMMER 1961:
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As concrete crews poured and spread, electricians unrolled pre-assembled Sno-Melter mats right behind them.

While concrete sections were leveled, well-tagged Sno-Melter lead wires were fed into pre-arranged junction boxes. Electricians were out of way by time top 1½" of concrete was poured.

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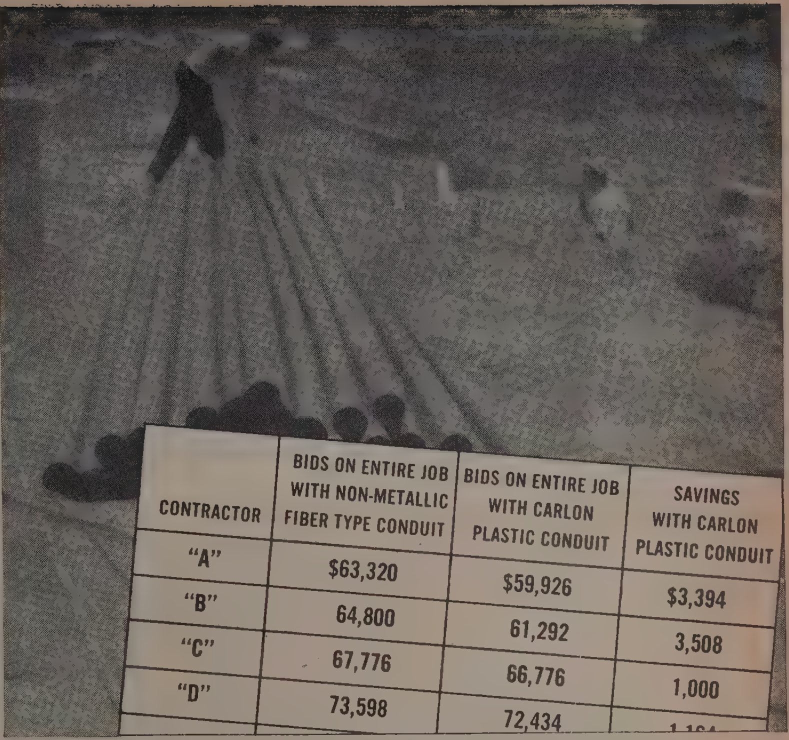
"Electric Snow Removal Equipment"
Dept. ECM, New Carlisle, Indiana



CONTRACTOR	BIDS ON ENTIRE JOB WITH NON-METALLIC FIBER TYPE CONDUIT	BIDS ON ENTIRE JOB WITH CARLON PLASTIC CONDUIT	SAVINGS WITH CARLON PLASTIC CONDUIT
"A"	$63,320	$59,926	$3,394
"B"	64,800	61,292	3,508
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"D"	73,598	72,434	[illegible]

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Competing contractors on a recent state university installation were able to allow savings of as much as $25/100′ on Carlon Plastic Conduit as compared with another type of non-metallic duct because . . . Carlon's 30-foot length eliminates two joints, lowers installation costs . . . Carlon's solvent weld joints are quick, easy, and permanent, require no tapering . . . cables easily glide through Carlon's smooth interior walls and joints, will not bind or snag . . . Carlon saves handling too, one worker can carry as many as six 30-foot lengths at one time.

Non-magnetic, corrosion-resistant, fire-resistant, Carlon Plastic Conduit cuts costs and increases job quality on all types of installations, underground and imbedded in concrete.

Get the facts on Carlon's entire line of Plastic Conduit and Fittings . . .

Carlon Underground for concrete encasement and direct burial; competes with other non-metallic conduits.

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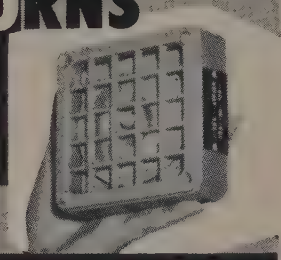


When received, your VIBRATONE horn is tuned for maximum volume. You do not need special horns for the less noisy locations. The same horn can do either.

A few turns of the adjusting screw gives you any desired volume down to a whisper, for factory, school, office or hospital.

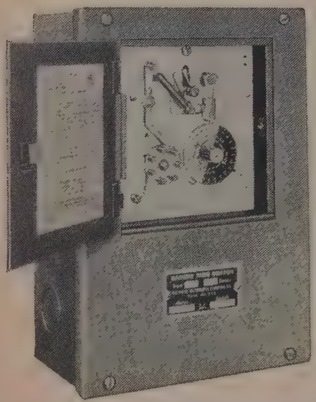
The VIBRATONE adjustment doesn't dampen the diaphragm and throw the horn out of electrical balance to shorten its life. It maintains electrical balance with reduced current to provide a softer tone and increase its life.

This is another reason why VIBRATONE HORNS give longer trouble-free service. *Whatever the application, VIBRATONES can solve your signalling problem.* Write for Bulletin #105, TODAY!

FEDERAL SIGNAL SIGN and Corporation

13626 S. Western Ave., Blue Island, Ill.

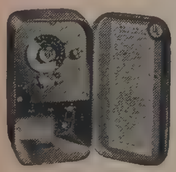
SPECIFY RELIANCE TIME SWITCHES



- Three basic models satisfy 90% of all applications.
- Only Reliance has a T-rated 70 ampere switch
- Reliance assures full scale quality at competitive prices

BADGER 70 BECOMES NEWEST STANDARD

Featuring rugged construction, the Badger has *Dura-treated* copper contacts with pressure type terminals. Heavy non-ferrous gears run with steel pinions. Heavy-duty synchronous motor for indoor or outdoor installation. NEMA standard cabinets, flush or surface mounted. Vernier time set. Optional features include omitting device, extra trippers and one-hour dial.



MODEL 400

Reliance also manufactures a full line of general purpose time switches. These include the versatile 30 amp. Model W and the budget-priced 40 amp. Model 400. Model W is available in 7 standard types. Silver contacts. Non-ferrous gears run with steel pinions. One piece, deep drawn steel cabinet with hinged cover. Combination knockouts. One or two circuit control. Model 400 has all the convenience features of higher priced models.

Write for Latest Descriptive Literature and Prices

RELIANCE TIME CONTROLS, INC.

1937 Mead Street • Racine, Wis.

ELECTRICAL INSPECTOR W. C. Whitney, president Minnesota Chapter, IAEI, opens Wiring Codes Session at recent Upper Midwest Electrical Industry Convention in Minneapolis. At right is panel moderator H. B. Love, Detroit, president of Western Section, IAEI.

Western Electronic Show & Convention — Memorial Sports Arena, Los Angeles, Calif., August 21-24.

American Home Lighting Fixture Month—National promotion, September 1-30.

Illuminating Engineering Society—National technical conference, Statler-Hilton Hotel, Dallas, Texas, September 9-14.

Canadian Electrical Mfrs. Assn.—Annual meeting, Sheraton-Brock Hotel, Niagara Falls, Ont., October 3-5.

International Assn. of Electrical Leagues — 27th annual conference, Sheraton-Chicago, Chicago, Ill., October 3-5.

National Electrical Contractors Assn. —Minneapolis Auditorium, Minneapolis, Minn., October 7-13.

National Electronics Conference—McCormick Place, Chicago, Ill., October 8-10.

Rocky Mountain Electrical League—Fall convention, The Broadmoor, Colorado Springs, Colorado, October 14-18.

Electrical Manufacturers Trade Show —Indiana State Fair Grounds, Indianapolis, Ind., October 23-25.

National Electrical Manufacturers Assn. — Annual meeting Shoreham Hotel, Washington, D. C., week of November 12.

Building Research Institute—Fall conference, Mayflower Hotel, Washington, D. C., November 27-29.

Electrical Engineering Exposition — Sponsored by AIEE, Coliseum, New York, N. Y., January 28-31, 1963.

16th International Heating & Air-Conditioning Exposition—Coliseum, New York, N. Y., February 11-14.

4th Southeastern Plant Engineering and Maintenance Exposition — Merchandise Mart, Charlotte, N. C., March 5-7.

You Don't Need

BOLTS NUTS

WASHERS PINS

or Special Tools to install

Cable Support Systems

Power circuits . . . process tubing . . . piping . . . control cables . . . are better, faster, more economically supported with Chalfant engineered systems.

Exclusive crimp-type splice plates securely join Chalfant trays without the need of bolts, washers, nuts or pins. This is only one of the features that drops installation time way down over conventional installation methods.

Chalfant uses Aluminized steel to make Trays and Splice Plates. It's a high quality, longer lasting, stronger material that is outstanding in performance yet lower in price.

You'll be years ahead by specifying Chalfant Aluminized Steel Cable Racks for your jobs to . . .

SAVE . . .

15% on Material

40% on Installation

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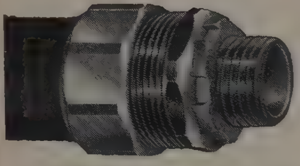
11521 Madison Ave. • Cleveland 2, O.

IDEAL

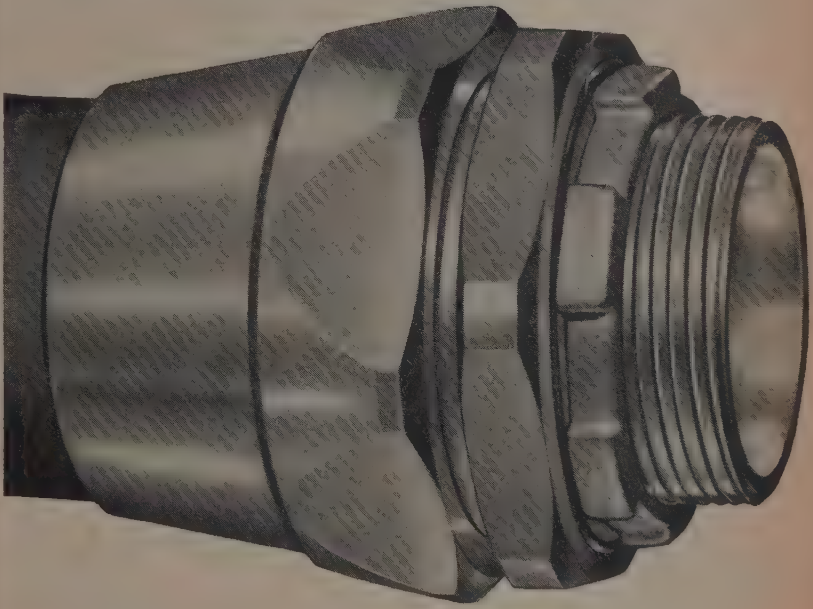
VAP-OIL-TITE CONNECTORS

- *for use with liquid-tight flexible, metallic conduit*
- *absolute water and oil-tight seal — vapor, dust, grit can't penetrate*



STANDARD SIZES — ⅜" to 2"
Available in 3 styles — straight, 90° angle and 45° angle. U.L. and J.I.C. approved. Fit both EF and UA conduit. Seven sizes for each style from ⅜" to 2" conveniently packaged in lots of 5 to 100, or by carton . . . priced right!

LARGE SIZES—2½", 3", 4"
Straight style only. Double O-ring neoprene seals prevent foreign matter penetration—**nothing can get through!** Extra long skirt prevents damage to conduit. Three sizes, 2½", 3" and 4" packaged individually — at the right price!



EASIEST TO APPLY--NEVER PULL APART

The *only* completely reusable connectors for OEM, replacement and maintenance, and machinery applications where a positive seal against water and oil is a must!

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Straddle-Trestle Rolling Tower

Work in safety over desks, machinery and other obstructions, on a Safway rolling tower equipped with straddle-trestles. Two-foot-wide tower rolls easily through doorways or narrow isles, can be built up to 12′ height. Wider frames also available for higher towers. Easy-rolling rubber-tired wheels are equipped with safety-locks and screw-jacks for height adjustment or leveling on uneven surfaces.

TAKE YOUR CHOICE
- Sturdy steel or lightweight aluminum
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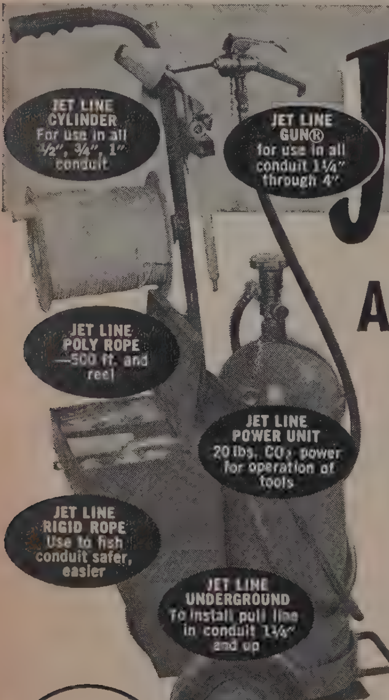
2310 lbs. capacity with Safload Platform
New Safload steel work platform provides 2310 lbs. uniform load capacity or 1150 lbs. concentrated load capacity with 7-foot-wide straddle-trestle.

See your local Safway dealer, or write for Bulletin 85F. SWP-40

SAFWAY

SAFWAY STEEL PRODUCTS, INC.
6228 West State Street • Milwaukee 13, Wisconsin



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JET LINE GUN® for use in all conduit 1¼″ through 4″
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JET LINE POWER UNIT 20 lbs. CO₂ power for operation of tools
JET LINE RIGID ROPE Use to fish conduit safer, easier
JET LINE UNDERGROUND To install pull line in conduit 1¼″ and up

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A ONE-MAN GANG
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Here's the all-new Jetmaster—combining the entire Jet Line Method* into one handy, compact, easily portable unit! On any wire pulling job, with Jetmaster you'll have *all* the Jet Line tools, accessories and power you need —right at your fingertips. Jetmaster saves countless hours (and dollars), helps you pull wire quickly, easily, safely in any size, any type conduit from ½″ through 4″ I. D.

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CATALOG NO. 1210
**Jet Line Gun method and apparatus covered by basic patent No. 2,930,584*

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Among the Manufacturers

Headquarters Announcements

Mica Insulator has changed its name to the **Mico Div. of Minnesota Mining and Mfg. Co.,** Schenectady, N. Y.

Sola Electric Co., Elk Grove Village, Ill.—John V. McGuire, senior vice president and general manager; Clemens J. Czapinski, Jr., manager of marketing services.

Minnesota Mining & Mfg. Co., St. Paul, Minn.—Dr. C. W. Walton, vice president for research and development; J. W. Selden, division vice president of new products commercial development.

James G. Biddle Co., Philadelphia, Pa.—Robert S. Kennedy, product planning manager.

Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.—Dean B. Randall, director of merchandising; Paul W. Felt, manager of operations for Commercial Div.

Clark Controller Co., Cleveland, Ohio—William J. Suk, sales manager, Standard Products Div.

Volkswagen of America, Englewood Cliffs, N. J.—Frederick J. Talento, sales promotion manager; Henry J. Harman, car merchandising manager; Rendel W. Smith, manager of Sales Organization Dept.

General Electric Co., Schenectady, N. Y.—Maurice C. Sublette, manager of sales, Industrial Motor and Generator Product Section, Direct Current Motor and Generator Dept., Erie, Pa.; R. B. Wall, manager of pump, fan and compressor industries sales.

Silvray Lighting, Inc., New York, N. Y.—James M. Gilbert, chairman of the board and chief operating officer; Robert L. Levenstein, president.

Thomas & Betts Co., Inc., Elizabeth, N. J.—Edward C. Hewitt, vice president and general sales manager.

Warner Electric Brake & Clutch Co., Beloit, Wis.—Leland W. Ruffner, manager of operations.

University Loudspeakers, Inc., White Plains, N. Y.—Norman Sanders, regional sales.

J. I. Case Co., Racine, Wis.—R. I. Hahn, board of directors.

Simplex Wire & Cable Co., Cambridge, Mass.—John W. Logan, president and chief executive officer.

Appleton Electric Co., Chicago, Ill.—Phillips M. Darby, vice president-general sales manager.

TESTS PROVE:
10% more slip
with
Y-ER EAS
Wire Pulling Lubricant
For Lead, Rubber, Braid or Synthetic Covered Cables

There is only one Y-ER EAS

Don't accept substitutes. The extra slip means extra savings on every job.

- Creamy, non-corrosive. Never greasy or messy.
- Prevents sticking or setting. Extra slip for saddles and turns.
- Does not run back on cables.
- Never harmful to hands, clothing, cables or conduit.

NEW! ALUM-N-EAS
Thread lubricant stops binding of aluminum conduit connections!

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YOU CAN FEEL AND SEE THE

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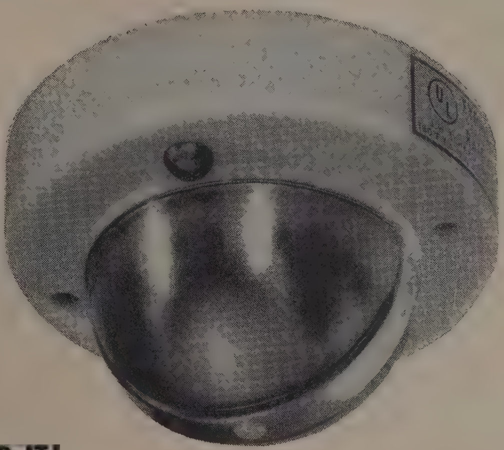
Today a dead loss —

SELL CUSTOMERS
KIDDE FIRE DETECTION—



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EXPANDABLE—EFFICIENT Kidde FYRINDEX, built around the compact detector shown above, is an expandable system that can serve one room or acres of factory space. Customers like the FYRINDEX. It not only responds quickly, but can be heat tested periodically without damage. Customers can also paint the FYRINDEX detector without impairing its efficiency. It is unaffected by dust, humidity, corrosive air particles and vibration.

SIMPLE—

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FOR MORE INFORMATION—get in touch with your electrical wholesaler or write direct to Kidde.

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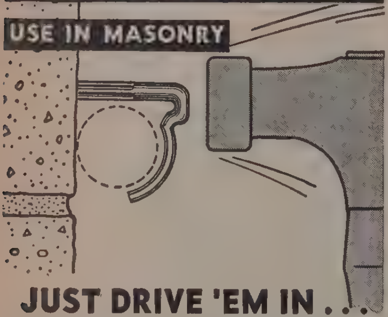

JUST DRIVE 'EM IN . . . AND DO THEY HOLD!

VERTICAL THREADS (hardened steel — electroplated). Drives like a concrete nail into concrete block, green concrete, cinder block, mortar and similar materials.

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ANNULAR THREADS (regular steel—electroplated). Threads "lock" with the wood fibres for up to 3-times greater holding power.

SIZES FOR EVERY JOB . . . AND EVERY MATERIAL

- DRIVE EASILY
- WON'T BREAK
- NEVER LOOSEN
- COST LESS!

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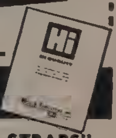

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Bishop Mfg. Corp., Cedar Grove, N. J.—Harmon H. Gillman, vice president for research and development.

Gamewell Co., Newton Upper Falls, Mass.—James C. Hicks, manager of the municipal sales section, General Sales Dept.

Royal Electric Corp., Pawtucket, R. I.—Glenn W. Bailey, president.

Leach Corp., Compton, Calif.—Robert L. Jannen, vice president of sales.

Dayco Corp., Dayton, Ohio—Joseph B. Maxson, sales manager, Industrial Dept., Rubber Products Div.

International Resistance Co., Philadelphia, Pa.—J. Burton Henry, director of sales and marketing.

Sylvania Electric Products Inc., Salem, Mass.—Dan E. Picini, product marketing specialist for Panelescent lighting; Harold L. Barnum, marketing manager, Industrial Commercial Sales; Leslie E. Innis, All-product manager—Large Lamps; Lighting Products Div.

Siegler Corp., Paramus, N. J.—Gerhard E. Kadisch, vice president of marketing, Bogen-Presto Div.

Regional Appointments

NEW ENGLAND

Black & Decker Mfg. Co.: Roger C. Hildebrand, branch service manager at Hartford, Conn.

MIDDLE ATLANTIC

Allis-Chalmers Mfg. Co.: R. E. Persohn, general manager of Pittsburgh works.

Thomas & Betts Co., Inc.: B. R. Conner, district manager of Philadelphia.

Permacel: Donald A. Wallace, field sales manager for the metropolitan New York-New Jersey area.

Eutectic Welding Alloys Corp.: Robert F. Fox, eastern sales manager headquartered at Flushing, N. Y.

Harvey Aluminum: H. Litman & Son, Yonkers, N. Y., representative for New York City metropolitan area; R. E. Needham, Pittsburgh, Pa., representative for northwestern Maryland, western Pennsylvania, Columbiana and Jefferson Counties, Ohio and state of West Virginia.

International Resistance Co.: Felix T. Troilo, eastern district sales manager.

Rawlplug Newark Co.: Joseph A. Mruk, branch manager at Newark, N. J.

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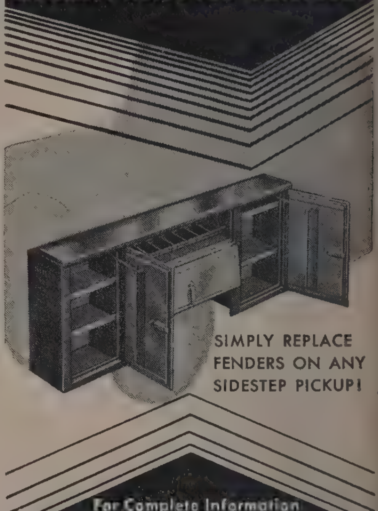

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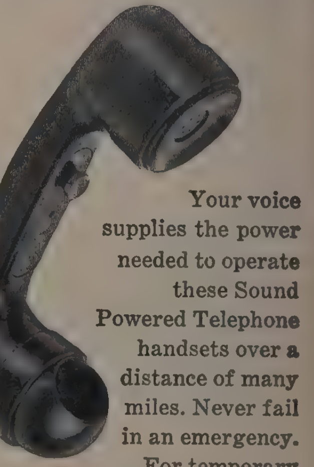
PHONES

that need no current



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- Porcelain Enamel Finish
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CATALOG No. 9A

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Litecontrol Corp.: Richard Knight, Woodbury Heights, N. J., representative for Philadelphia, eastern Pennsylvania, Delaware and southern New Jersey.

Stanley Works: Howard J. Beers, sales representative in the New York metropolitan area, Power Tools Div.

University Loudspeakers, Inc.: Norman Sanders, regional sales manager for central United States.

SOUTH ATLANTIC

Litecontrol Corp.: John Asher, Baltimore, representative for Maryland.

Sylvania Electric Products Inc.: James C. Redifer, Florida representative of Lighting Products Div.

Wiremold Co.: F. A. Navazio, sales representative for Washington, D. C. territory.

Pfaff & Kendall: Signal Associates, Inc., Miami, representative for Florida.

EAST CENTRAL

Allis-Chalmers Mfg. Co.: John M. Crawford, general manager at Gadsden, Ala., works.

Harvey Aluminum: Ira L. Arkin Co., sales representative for southeastern Wisconsin, northern Illinois and northwestern Indiana; Riecher Electric Sales Co., sales representative for Michigan.

Pfaff & Kendall: J. E. Nelson Inc., Indianapolis, sales representative for Indiana and Kentucky.

G&W Electric Specialty Co.: Glenn Associates, Inc., Birmingham, sales representative for Alabama and northwestern Florida.

Eutectic Welding Alloys Corp.: R. H. Groman, central sales manager headquartered in Moline, Ill.

Sylvania Electric Products Inc.: William LaPelle, Chicago district fixture sales supervisor, Lighting Products Div.

Sunbeam Lighting Co.: Wesley E. Mattox, Chicago district sales manager.

WEST CENTRAL

Harvey Aluminum: Arbeiter Co., St. Louis, sales representative for southern Illinois and eastern Missouri.

Ward Leonard Electric Co.: Earl K. Moore Co., New Orleans, representative in Louisiana, Mississippi, Arkansas and western Tennessee.

Pringle Electrical Mfg. Co.: Gregory-Salisbury & Co., New Orleans, representative in Mississippi, Louisiana and western Tennessee.

Sylvania Electric Products Inc.:

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BAKELITE • SCREW-ON

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A real he-man's connector—thick, strong wall and skirt prevent damage, even under severe pressure. Copper coated steel insert...wide, deep-threaded throat. Precision made. No loose springs—no duds!

U.L. Listed as pressure cable connectors for general use — in all types of branch circuit wiring up to 600V (1000V in fixture or sign).

3 SIZES

. . . safely handle hundreds of combinations of No's. 18-10 solid and/or stranded wires.

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BAKER SCAFFOLDS

Profits are elusive most of the time—but not when you're using Baker Scaffolds. You actually gain profits because of time saved.

Baker Scaffolds are built full of features that save money and time. Most important are the many features that speed up the job—portability, adjustability, adaptability and just plain handy—and Baker Scaffolds are durably built for safety—and for a long useful life.

You can do many things with Baker Scaffolds that can't be done with other scaffolds. Roll through doorways, over obstacles on the floor or use them on stairways. Platform adjusts in 3-inch increments from bottom to top.

Really, the best way to see how Baker Scaffolds can save is to use them . . . and that, too, is easy. There's a distributor near you . . . or write direct to the factory for more complete information.

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DISTRIBUTORS IN PRINCIPAL CITIES

VINCENT McBRIDE, consulting engineer, Lebanon, Conn., tells Illinois electrical inspectors of new conduit-fill conductor-temperature investigation. Limited tests already indicate conductors operate cooler as percent conduit fill increases and when brightness of conduit inner surface is reduced. Additional study of related heat transfer factors is planned, he noted.

Marvin A. Carlson, central area fixture operations sales representative for Minnesota, North Dakota and parts of South Dakota, Wisconsin and Iowa, Lighting Products Div.

R. E. Dietz Co.: G. M. Baird and Co., Dallas, representative for Arkansas, Louisiana, Oklahoma and Texas.

J. A. Weaver Co.: J. W. Gatchell, Kansas City, sales representative for Kansas and western Missouri; Elmer E. Scheetz, St. Louis, Mo., sales representative for southern Illinois.

WEST

Clark Controller Co.: Electrical Agencies Co., Denver, sales representative for Colorado and Wyoming.

Eutectic Welding Alloys Corp.: John W. Reuter, western sales manager, headquartered in Oakland, Calif.

Jack & Heintz Div., Siegler Corp.: Charles R. Dunfee, manager of Los Angeles office.

Gamewell Co.: Kenneth R. Herman, regional sales manager located at San Leandro, Calif.

Sylvania Electric Products Inc.: Robert W. Thunnen, regional marketing engineer on the west coast; William K. Chapman, sales manager of San Francisco district.

Owatonna Tool Co.: James C. Nelson, district manager for 12 county territory south of San Francisco.

Ward Leonard Electric Co.: Thatcher Electronics, Colorado Springs, Colo., representative in Rocky Mountain area.

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Quality-Service Since 1930

A broad line of Masonry Fasteners and Masonry Drilling Devices

See your nearest Distributor or write

ARRO EXPANSION BOLT CO.
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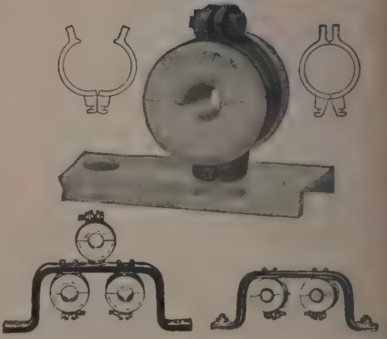
FOR QUICK, EASY Cable Installation "EFFICIENCY" NESTED CONDUCTOR RACKS



Nested conductor racks are compact and scientifically designed to carry cables equidistant from center to center. Available in 2, 3, 4, 5 and 6 bushing racks.

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ELECTRIC & MFG. CO.
EAST PALESTINE, OHIO

THIEL STAPLES ARE STANDARD SIZE, BUT MADE OF HEAVIER MATERIAL

FOR LESS MONEY!

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The New Hump Drive-It Strap has a sturdy head to insure Easy-Drive without bending or pulling out. Made of No. 8 heavy wire. Zinc plating prevents rust.

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CONTROL one OR many AC MOTORS—TO THE RPM!

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QUALITY DESIGNED
AIR COOLED — DRY TYPE
TRANSFORMERS
CLASS B
80°C RISE
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Single and 3 Phase
Insulating Indoor
Sizes ½ to 1000 KVA
Voltages
up to 15,000 V.

Highest quality performance . . . years of dependable service . . . priced to save you money . . . those are the advantages of UTILITY DRY TYPE TRANSFORMERS. They're fully guaranteed for 3 years, too. Investigate the advantage of installing Utility Transformers now, you'll be glad you did.

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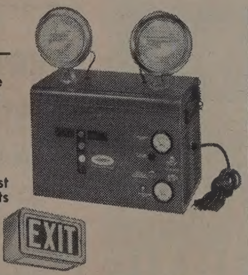
No. 2-FA—Automatic fast charge emergency light • Lead acid or nickel cadmium battery • Manual fast charge units available*



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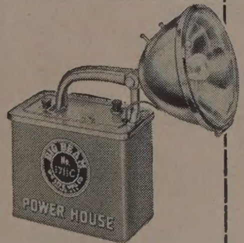

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Powerful BIG BEAM hand lamps, flares and emergency lights fit every requirement! Finest quality . . . American made.

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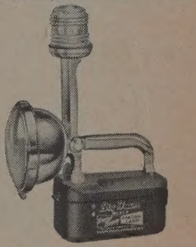

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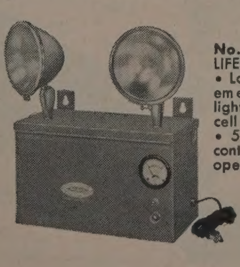

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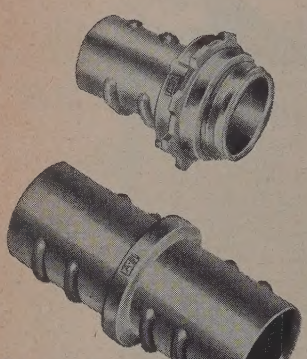

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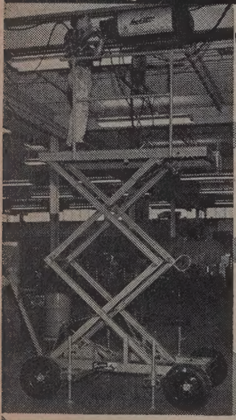

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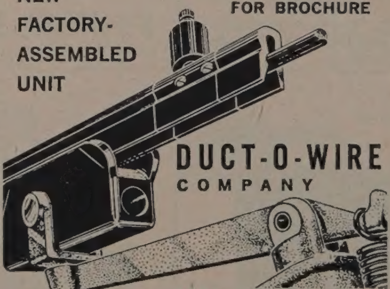

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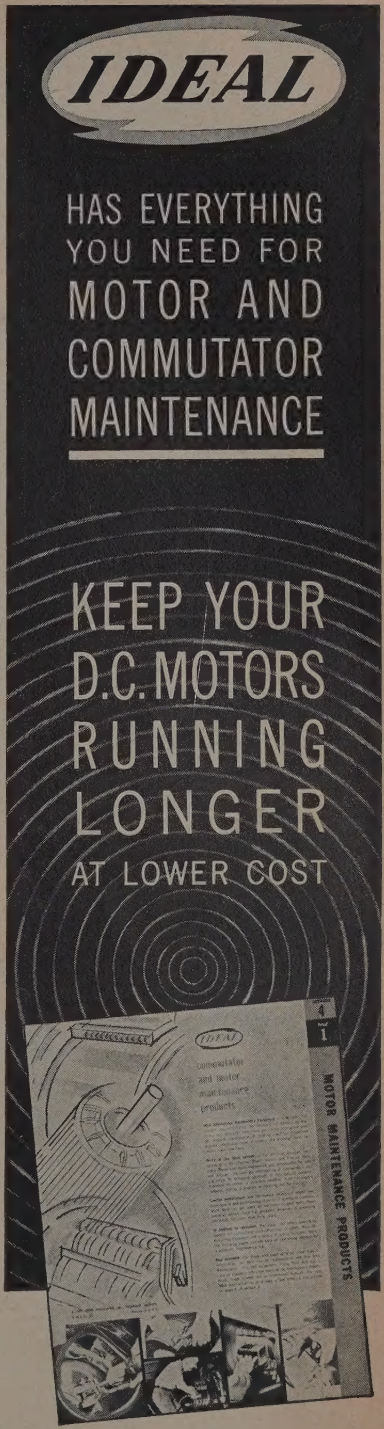

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